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BULLETIN

OF THE

TORREY BOTANICAL CLUB

VOL. 50

FOUNDED BY WILLIAM HENRY LEGGETT 1870

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NEW YORK
1923
PUBLISHED FOR THE CLUB
THE INTELLIGENCER PRINTING COMPANY
LANCASTER, PENNSYLVANIA

CONTENTS

Dates of Publications

No. 1, for January.	Pages 1– 60	Issued February 7, 1923.
No. 2, for February.	“ 61– 94	“ February 23, 1923.
No. 3, for March.	“ 95–132	“ March 16, 1923.
No. 4, for April.	“ 133–158	“ April 7, 1923.
No. 5, for May.	“ 159–196	“ May 25, 1923.
No. 6, for June.	“ 197–230	“ July 6, 1923.
No. 7, for July.	“ 231–260	“ July 27, 1923.
No. 8, for August.	“ 261–282	“ August 17, 1923.
No. 9, for September.	“ 283–316	“ October 23, 1923.
No. 10. for October.	“ 317–342	“ November 19, 1923.
No. 11, for November.	“ 343–372	“ December 3, 1223.
No. 12, for December.	“ 373–414	“ January 24, 1924.

Errata

Page 17, line 3 from bottom, for “*Marsilia*” read “*Marsilea.*”
Page 70, line 6, for “*leicocarpa*” read “*leiocarpa.*”
Page 68, line 11 from bottom, for “*neomeaiana*” read “*neomexicana.*”
Page 70, line 17, for “*Maximiiliani*” read “*Maximiliani.*”
Page 95, line 2 from bottom, for “60” read “61.”
Page 114, line 4, for “*terebinthinaceus*” read “*terebinthinacea.*”
Page 135, headline, for “*Oenoethra*” read “*Oenothera.*”
Page 167, line 17, for “Linn” read “Lane.”
Page 168, line 19 from bottom, for “*Lipinus*” read “*Lupinus.*”
Page 201, line 6, for “*Marsilia*” read “*Marsilea.*”
Page 211, line 18, for “*Dobinia*” read “*Dobinea.*”
Page 213, line 1, for “a late” read “alate.”
Page 269, line 21, for “*A. gaviotus*” read “*H. gaviotus.*”
Page 270, line 4, for “*S. filipes*” read “*H. filipes.*”
Page 270, line 11, for “*Nivius,*” read “*Nevius.*”
Page 271, line 6, for “CONOVIRENS” read “CANOVIRENS.”
Page 278, line 1, for “517, 559” read “517,559.”
Page 290, line 16 from bottom, for “*Stenolepsis*” read “*Stenolepia*” and for “*Nephrolepsis*” read “*Nephrolepis.*”
Page 292, in legend under figure, for “*imbricatus*” read “*imbricata*”
Page 344, lines 15 and 17 from bottom, for “f”. read “s”.

Vol. 50 No. 1

BULLETIN

OF THE

TORREY BOTANICAL CLUB

JANUARY, 1923

The histology of certain orchids with reference to mucilage secretion and crystal formation

Edna L. Smith

(with plate 1)

The subject of mucilage secretion in plants is one which has been discussed from several points of view. The relation of the mucilage to growth, to the prevention of loss of water by transpiration, its possible rôle as reserve food material, its chemical composition, its origin, the processes in connection with its formation; all are questions as to plant slimes which are still disputed. The relation of raphides to cell mucilage is undetermined, although it has long been noted (Frank, Stahl, Walliczek, Tschirch and others) that mucilage occurs in cells which bear raphides.

Frank (1867) distinguished plant slimes as gums and mucilages and recognized three general types. First, those from the protoplast; second, those deposited by the cell wall; and third, those which occur in intercellular canals. He described the mucilage in several species of orchids as being derived from the protoplast, since, as he observed, there is invariably a thin layer of cytoplasm and the nucleus between the mucilage and the cell wall. Frank also observed the association of raphides and mucilage in the cells of orchids.

Stahl (1888) considered slime in crystal-bearing cells as a reserve food supply, a protection against being eaten by animals, and a water regulator. The matter of its origin he does not attempt to settle.

[The Bulletin for December (49: 349–407) was issued January 27, 1923.]

Gardner and Ito (1888) believe that the mucilage in the fern hairs of *Blechnum occidentalis* and *Osmunda regalis* is a product of the cell contents and that it is secreted as drops in the cytoplasm until the protoplast is exhausted, only a thin layer of the cytoplasm remaining.

Groom (1893) notes in a discussion of bud protection in dicotyledons: "The employment of a hygroscopic substance like mucilage is an admirable means of controlling the water supply of an organ for two reasons; first, the osmotic power of a solution increases with the concentration of the solution. Therefore, when the bud is in the greatest danger of losing all the water; when the temperature is high and a considerable amount of water has been evaporated from the mucilage, the remaining water is held most firmly, and a supply of water is absorbed most fiercely." He ignores the relation of the colloidal character of the mucilage to the imbibition of water. Were the principle of osmosis the only one involved here, the cells of the young buds would need to be vacuolated, as mucilage cells are predominantly reported not to be.

Tschirch (1889 and 1908) distinguishes between cellulose slime and true slime and gums. He further differentiates them under the headings: epidermal slime (*Cydonia*, *Salvia* and *Linum* seeds), slime of the outer wall (alga and fungous mycelium slimes), slime of the intercellular spaces (*Tilia*, Malvaceae, *Laminaria*), cell content slime (*Orchis* tubers), schizogenous excretions (cycads, *Aralia*, *Laminaria*), and lysigenous excretions (*Acacia*, *Prunus*, *Sterculia*). In some cases he found empty slime cells which he took as an indication that the contents had been taken up again in the metabolism. The resins, he says, originate in a special layer of the wall, to which the material for making resin is brought, and calls this the resinogenous layer.

Walliczek (1893) distinguishes gums, epidermis slime, cell membrane slime, and cell content slime. Of this last type of mucilage in connection with the Polygonaceae he says that he found slime in cells bearing raphides whose development here as in the case of all other such slimes is not certainly known. The forms which he studied did not contain such slime, so he has left this question as he found it. He confines his research to the slime in the vegetative organs, especially the epidermal cells of the leaves and the inner tissues of the vegetative organs, since he considers that the epidermal slime of seeds and endosperm slime has been shown to originate from the secondary thickening of the cell wall. He recognizes four types of epidermal slimes, as follows:

1. The inner wall thickened by a secondary slime membrane (*Althea rosea, Quercus pedunculata, Malva vulgaris, Cornus mas*).
2. The inner wall thickened by a secondary slime membrane and upon this a tertiary cellulose lamella (several species of *Cassia, Ulmus glutinosa, Corylus Avellana, Arbutus unedo* are a few examples). This type is the most common of the four.
3. The inner and outer walls thickened by a secondary slime membrane and upon this a tertiary cellulose lamella, the side walls also thickened (*Salix alba* the only example of this type known to Walliczek).
4. The lower cell wall thickened by a secondary slime membrane and a tertiary cellulose membrane, a quaternary slime membrane, a fifth cellulose membrane and so forth up to ten layers which was the largest number observed (*Barosma vulgaris, B. crenulata, B. serratifolia, B. crenata,* and *B. betulina*).

In all cases the slime membranes give the reactions of what Walliczek calls true slime from their first occurrence. These reactions are swelling in water, precipitation by alcohol, and not staining blue with iodine and sulphuric acid. Cellulose slimes are described by him as staining blue or violet with these reagents. Only the mucilage of the seed epidermis of crucifers, of *Cydonia* and of *Salvia* have been proved to be of this sort.

Walliczek in considering the slime membranes in the inner tissue of vegetative organs notes that with certain treatments plant slimes which are to be regarded as arising in the form of secondary thickenings show stratification, and that this stratification is the best morphological distinction between cell membrane slime and cell content slime. The latter appears quite homogeneous ("*Orchis*-Schleim", "Raphiden-Schleim"). He notes, however, that proof of the origin of cell content slime is certain only in *Symphytum* and *Orchis*. There may be also cell membrane slimes which do not show stratification. Walliczek cites the slime of *Tilia grandiflora* as an illustration, though it is generally classed as a cell membrane slime. In the later stages at least he notes also that all slimes may be more or less dissolved and that in the stages of solution the stratification disappears.

Walliczek studied the slimes of the inner vegetative tissue of *Tilia grandiflora*, *Tilia parviflora*, *Hibiscus syriacus*, *Theobroma Cacao*, *Althaea taurinensis*, *Rhamnus Frangula*, and the following, cacti: *Epiphyllum*, *Echinopsis Eyriesii*, *E. multiplex*, *Mammillaria densa*, and *Opuntia Tuna*. In no case does he consider these as cell content slimes, although in discussing the slime of cacti he says that the mucilage is laid down upon the primary wall as a secondary thickening, but that the primary wall has no active part in the process, and that the cytoplasm, as the laboratory of the cell, is in each case (species of *Epiphyllum*) the builder of the deposits of slime, which are, however, never found within the primordial utricle but always outside it.

He describes the stages in the development of the mucilage cells in *Tilia grandiflora*, these including the enlargement of the cells and the increase in density and amount of the cytoplasm and nucleus. By the deposit of mucilage these are pushed to the center of the cell and finally in the mature cell have the appearance of undergoing disintegration. He says the slime is laid down centripetally, that when it dissolves the inner part disappears first, and that during their development neither the slime cells nor those surrounding them contain chloroplasts or starch. The process of mucilage formation is a very quick one. Later the mucilage begins to dissolve and the dissolved slime seems to be changed into starch. At least the slime cells of the cortex in *Tilia grandiflora*, which show stages of mucilaginous disintegration, are densely filled with starch, as are also the neighboring cells and no others. He has studied the history of the slime cells in this species with reference to their changes with age and concludes that noticeable changes may not occur until the third year, when the slime cells may show only traces of stratification on the primary cell wall. In other cells the disappearance of slime was much longer delayed and he found eight year old slime cells which were little changed in appearance from newly formed ones, though his general conclusion is that in all cases the slime of the inner tissue is at least in part dissolved and taken up in the metabolism.

In the case of *Scilla maritima*, *Symphytum officinale* and *Orchis* tubers he thinks without doubt that the slime is a store of reserve food (Tschirch). The function of slimes in general he thinks is that of storing water which can be distributed to the surrounding tissue in time of need.

Schilling's view (1894) as to the function of slime cells in water plants was that they are water regulators for the young parts without a protective epidermis, which disappear as soon as the outer tissue has developed.

Kohl (1899) has given an extensive account of raphides and their relations to plant slimes. In summary he finds that they consist of calcium oxalate; that they belong to the monoclinic system (though they are in many cases impossible for a crystallographer to define because of the smallness of the needles, their large angles and the curvature of the crystal face); that they appear very early in the development of the organ in which they occur, having been observed one millimeter from the growing point; that the number of cells containing them increases with the unfolding of the plant part; and that as soon as the cell bearing them has reached its typical form it remains relatively unchanged during its whole subsequent existence. Kohl notes that in the course of his observations he has never found that the raphides disappear. He describes their development as follows: they originate in vacuoles singly or in numbers, each crystal being ensheathed in a plasma membrane, and the mature bundles being bound together in a cytoplasmic sheath attached to the primordial utricle by cytoplasmic strands. The nucleus in the mature cell is commonly pushed to one side while the crystals occupy the center of the cell, which enlarges during the development of the raphides and usually in a longitudinal direction. In some forms cells bearing raphides have been observed which are twenty times longer than wide (*Vanilla planifolia*). Sometimes when these cells occur in series, the cross walls between them may disappear entirely, due to their vigorous growth in length. According to Kohl the crystals remain unchanged in size and number until the cell disintegrates. Sooner or later these cells contain a homogeneous translucent slime. He says, "Dieser Schleim ist es jedenfalls, welche die den Raphiden eigenthümliche Zusammenlagerung veranlasst." Kohl gives a list of plants which contain cells bearing raphides. This list comprises over one hundred species of monocotyledons and thirty-four species of dicotyledons.

Möbius (1908) attributed to mucilage in cells bearing raphides the rôle of protecting the protoplasm from injury by the pointed crystals.

Lloyd (1919), in a paper on mucilage secretion in the cacti, the Malvales and *Astragalus gummifer*, concludes that the slime is in each case a product of the primary cell wall. He considers the relation of slime to growth as very important since the early differentiation of slime cells in the region of the growing point indicates a mechanical function connected with the growth process, the slime cells constituting an imbibition apparatus which forces the membranes to stretch and thus acts as a factor of growth.

Miss Stewart (1919) has also investigated mucilage secretion in certain cacti. She concludes it to be a product of the protoplast since the middle lamella of the wall between the cells which bear mucilage and those which do not is equally distant from the protoplast in both cases, showing that the cell wall has remained unchanged in the slime cell. Her conclusion as to the relationship of mucilage to growth agrees with Lloyd's. In her description of the development of a mucilage cell she shows that the enlargement of the cell in the early stages is accompanied by increased density in the cytoplasm, and that the nucleus becomes larger, so that not only is there an increase in the volume of the cell, but the mass of material other than water is also augmented. As the slime cell becomes mature this dense cytoplasm with the nucleus is crowded to the centre of the cell and appears disorganized or may even disappear.

Czapek (1913 and 1921) recognizes:—

1. The slime which covers the epidermis of seeds, such as in *Linum*, the Lythraceae, and *Plantago*. This slime, he considers, arises from secondary thickening of the cell wall. It may exude from the cell upon the epidermis or into intercellular spaces.
2. The slime which arises from a specialized layer between the cell wall and the cytoplasm.
3. The slime which arises in the protoplast. Cells bearing raphides and the slime cells of various species of orchids belong to this class, which has been called cell content slime or mucilage. Czapek considers the protoplast slime cells in most of the epiphytic orchids as water containers. In the underground tubers of orchids as well as in the slime endosperm of many leguminous plants he looks upon these slime cells as stores of reserve carbohydrates.

The cell membrane slimes, he says, seem never to play the rôle of reserve food material, but to serve as imbibition mechanisms, a protection against excessive transpiration, a means of holding water during the germination of seeds, a mechanism for anchoring seeds to a substratum, a protection of water plants from animal enemies, and as facilitating gliding in growth.

The material chiefly used in the present investigations was buds and flowers of the orchid *Aspasia* sp., but more fragmentary observations were made also upon the orchids *Polystachya minuta*, *Oncidium stipitatum*, and *Orchis spectabilis*. *Aspasia* sp., *Oncidium stipitatum*, and *Polystachya minuta* were grown in the greenhouse of the botany department at Columbia University. *Orchis spectabilis* was collected May 1, 1921, near Tarrytown, New York.

In the study of the mucilage and the raphides paraffin sections of young buds and mature flowers were treated with a variety of staining reagents, mainly the triple stain of safranin, gentian violet, orange G.; the double stains, acid fuchsin and iodine green and safranin and aniline blue, were likewise found useful. Both fresh material and paraffin sections were also stained with ruthenium red, which brought out the middle lamella clearly. Fresh material was stained with corallin soda, methylene blue, and various aniline dyes, but all these observations on fresh material, while they corroborated the conclusions reached with the paraffin sectioned material, were not as satisfactory as the study of the microtome sections. The one determination which it was possible to make with fresh material and not with fixed was the number of crystals in bundles of raphides. When corallin soda is placed upon free hand sections of *Aspasia* sp. the mucilage in the cells containing crystals loosens up, making it possible to count the number of needles in a cell. In a large number counted the crystals varied from thirty to forty, most of the cells having from thirty-two to thirty-five. The variation seemed to be independent of the length of the bundles or the size of the cell in which they are borne, the small bundles having as large a number as the larger ones.

Cells containing mucilage and raphides were found abundantly distributed throughout the floral parts, longitudinally placed with reference to the long axis of the ovary. They were found fully developed in very young buds, showing that they are associated with actively growing regions. No slime cells in the process of development were found in the mature flowers. The region immediately surrounding the mucilage cells in young buds was characterized by actively dividing cells. All stages in the formation of mucilage were seen. The first indication that a cell will produce mucilage is the enlargement of the nucleus. The cytoplasm in such a cell is denser than in the neighboring cells and there is no large central vacuole. The cell has also enlarged somewhat. The measurements of cells which do not bear mucilage varied from 14 μ to 19 μ in width by 26–22 μ. Those which are enlarged in preparation for producing mucilage are 22–29 μ in length by 22–26 μ in width. The next stage in the development of the mucilage-bearing cell is the appearance in the enlarged cell of a small rather centrally placed vacuole. Before it has enlarged conspicuously a small bundle of raphides is formed in it. The raphides enlarge with the growth of the cell, which now stretches longitudinally. The average dimensions of such cells are 18.5 × 74 μ. The average dimensions of the bundles of crystals in these cells are 14.8 μ in width by 65.5 μ in length. The crystals are apparently suspended in the vacuole by strands of a substance which stains red with the triple stain and which also surrounds the crystal as a thin sheath. This envelope about the bundle in the mature cell is enlarged into a knob-like mass at the end of the bundle, in which highly refractive drops may sometimes be seen. Droplets of the same character were observed occasionally over the entire surface of the bundles of raphides giving the sheath a curdled appearance. The raphides have practically attained their ultimate size before there is any indication of the homogeneous yellow staining mucilage which finally almost fills the mature cell. The mucilage first appears as a thin layer inside the primordial utricle and surrounding the central vacuole. The mature cells have the following dimensions, in microns:

Mature mucilage cells in bud 8 mm. in length		Bundles of raphides in corresponding cells	
Width	Length	Width	Length
37	351	15	74
26	185	16	67
32	93	15	66
37	266	19	63

Mucilage cells in mature flower		Bundles of raphides in corresponding cell	
Width	Length	Width	Length
37	241	19	74
37	259	19	74
26	204	15	74
37	296	15	74

Such a cell contains a large bundle of crystals imbedded in a homogeneous mass of mucilage stained yellow by the orange of the triple stain. Between the mucilage and the cell wall there is a layer of cytoplasm in which the large nucleus with a conspicuous nucleole and chromatin is imbedded. In face view the nucleus is oval in outline and in profile view it is seen to be somewhat flattened against the cell wall. These nuclei appear quite normal. The chromatin takes the blue and the nucleole the red in the triple stain. The appearance of the nucleus in the mucilage cells of *Aspasia* sp. is very different from that described by Miss Stewart, Lloyd and Walliczek for the nucleus in the cactus slime cells. In the mature slime cell of the *Aspasia* it still has the aspect of an actively functioning organ; in the cactus the descriptions show that it is degenerating and lacking the normal differentiation into nucleole, chromatin, nuclear membrane, etc. There was no indication in the mature flower of any change in the character of the secretion in the mucilage cells. No chloroplasts or starch were observed in the slime cells. The only inclusions seen were small oval bodies which stained a bright red like the envelopes and strands of the bundles of raphides. In *Aspasia* sp. raphides and slime were always found associated and neither was found in a mature cell without the other. The crystals dissolved in hydrochloric acid without forming bubbles, showing that they are calcium oxalate. They were not observed in epidermal cells, and there was no evidence of their disappearance in the open flower stage. The sac about the bundle of raphides in no case observed took the same stain as the surrounding mucilage.

ONCIDIUM STIPITATUM

Abundant production of raphides imbedded in mucilage was observed in this species. The red staining sheath about the bundles was not as conspicuous as in the cells of *Aspasia* sp.

I observed no knob-like masses at the ends of the raphide bundles such as were found in *Aspasia* sp. Only buds were observed in this form. Further study is needed to determine the condition of crystals and mucilage in mature flowers.

POLYSTACHYA MINUTA AND ORCHIS SPECTABILIS

I can state that raphides associated with mucilage are found occurring plentifully in both these forms, but I have not as yet studied them cytologically.

The association of raphides with slime in the cell-content slimes has interesting and suggestive implications. Spoehr (1917), in discussing the pentose sugars in plant metabolism, points out that pentoses and hexoses are the most common forms of carbohydrates in plants and that they are transformed with ease and in multifarious ways into other compounds in the presence of organic salts, acids or alkalis. In the cell which produces raphides oxalic acid at least is obviously produced in excess and may be concerned in the transformation of sugar into a polysaccharide mucilage. Mucilages are generally considered to be polysaccharides of sugar, though O'Sullivan contends that mucilages and gums are not polysaccharides but glucoside derivatives of certain organic acids, the acid being different for each species producing mucilage. Hare (1911) claims that, so far as the opuntias which he analyzed are concerned, this view seems correct since the amounts of sugar and ash obtained were not sufficient to account for the total solids, and the residue from hydrolysis contained an undetermined organic acid. In this connection it is interesting to note that Bourquelot and Bridel (1920) discovered a new glucoside in *Orchis*, loroglossine, and that in eighteen species of native orchids which they studied glucosides were found abundantly. It is to be remembered, however, that the formation of a mucilage cell is a very complex process. It begins with the hypertrophy of nucleus and cytoplasm. The raphides appear before the mucilage does. Mucilage formation seems to follow the appearance of the raphides in the central vacuole. While the mucilage may be formed at the expense of the cytoplasm my preparations show most clearly that it is a secretion process and not one of mere degeneration. Whether slimes are polysaccharides or glucosides the evidence in the floral organs of *Aspasia* sp. is that the region of the raphides is a formative one since the envelope of the needles stains differently from the mucilage about it, and that drops of still different character are sometimes seen in the mass of material at the ends of the bundles as well as along their surfaces. The size of the crystals changes less during the life of the slime cell than the amount of mucilage does in the same period as a reference to the measurements of raphides and mucilage cells show. The normal appearance of the nucleus also indicates a living and active condition in the slime cell up to its mature condition. If the formation of mucilage in these slime cells is a continuous process during the life of the plant organ in which the cell occurs, the manner of secretion may be compared to that in the gland cells of animals which secrete continuously or periodically.

MacDougal (1920) claims that the measurements of variations in length and thickness of the succulent leaves of *Mesembryanthemum Phaseolus* and *Opuntia* yield ample evidence that the fluctuations in their growth show a direct relation to the hydration capacity of the growing cell masses, and that the high hydration capacity of *Opuntia* is due to the mucilage which it contains. The source of energy in hydration he attributes to the unsatisfied attraction of molecules or particles or ions bearing electrical charges. Polysaccharides, he says, appear to determine the water relations of living matter. He further says, "Growth consists in increases in volume of masses of living matter, usually but not invariably accompanied by accretions of material other than water to the colloids of the protoplasm." In the early stages of mucilage formation in the cells of *Aspasia* sp., just as Miss Stewart has shown for the cacti, there is obviously an accretion of material other than water as the increased size of the cell completely filled with dense cytoplasm proves. The transformation of this cytoplasm into slime may be a process of hydration and involves the imbibition of water from adjacent cells. If the process is simply one of imbibition of water it might better be regarded here as a degenerative rather than a growth process. As noted, however, my preparations show that the nucleus maintains its organization intact to the end. There is also a well-developed cytoplasmic primordial utricle in the mature slime cell, so that in my opinion we have here the case of a true secreting cell in which the material secreted is deposited in a central vacuole rather than being poured out into ducts as in the secreting glands of animals or being deposited between the plasma membrane and cell wall as is the cacti. During the later development of the slime cell, the assimilation of material other than water may be also going on if material (starch or sugars) from the adjoining cells is being made into mucilage.

The formation of raphides may be primarily dependent upon the supply of calcium in the soil (Kohl) and upon the supply of nitrates in the soil (Czapek). Oxalic acid may be formed in vitro by the oxidation of many carbon compounds with nitric acid. Czapek points out a connection between nitrates and oxalic acid in plants, saying that in certain forms it has been demonstrated that oxalic acid is produced abundantly when nitrates are given in excess, but that when nitrates are withheld, otherwise flourishing plants contain at most only slight quantities of oxalic acid.

As to the function of raphides, various views are held. Stahl believes them to be a protective device to prevent plants being eaten by animals, but subsequent studies by Leuvin (1901) have proved this theory unfounded. Groom (1896) suggests that the precipitation of calcium oxalate neutralizes the poisonous effect which potassium oxalate has upon plants. Czapek considers that in some cases at least raphides serve as reserve food stuff. In support of this view he cites Sorauer's report that these crystals disappear in the living cells of *Orchis* tubers, as well as DeVries's observation on ripening potato tubers and his own observation of the same phenomenon in *Begonia* cuttings.

The classification of plant slimes rests so far upon superficial appearance rather than upon inherent characters. This kind of grouping is probably responsible for the confusion in the literature dealing with them. Yet since the time of Frank (1867) three types have been clearly recognized. Tschirch (1889) substitutes "Schleime-epidermis" for Frank's intercellular class; Walliczek (1893) accepts this classification, finding great difficulty, however, in being definite about any slimes which have certainly been proved to belong to the cell content slime, including in this class only that which occurs in *Symphytum* and *Orchis* tubers; Kraemer (1908) recognizes cell content mucilage arising as a product of the protoplasm, and cell membrane mucilage derived from cell walls.

Plant parts with slimes belonging to the first class are apparently tubers of *Orchis* sp., rhizomes of *Agropyron repens*, bulbs of *Urginea maritima*, bulbs of *Allium* sp., stem and leaf elements of flowers (excepting stamens) of *Viola tricolor*, *Hagenia abyssinica*, *Musa paradisiaca*, and succulent plants such as the aloe.

Cell membrane mucilage Kraemer describes as either a degeneration of the cell wall or a secondary thickening, as an addition to the cell wall or some metamorphosis of it. Plant parts with slimes of this class are roots of *Althea officinalis* bark of cinnamon, bark of *Rhamnus Frangula*, rind of root of *Sassafras officinale*, inner bark of *Alnus Frangula*, pith and medullary ray cells of *Astragalus gummifer*, parenchyma cells of wood and bark of cherry and *Acacia senegal*, glandular hairs, leaf and calyx of *Viola tricolor* and leaves of *Coffea arabica*.

Czapek's classification of plant slimes as given above is probably the most complete and clearly formulated at the present time. Lloyd and Miss Stewart report raphides as occurring in certain species of cacti which by Czapek are classed as having cell membrane slimes. Whether or not cells bearing raphides sometimes contain mucilage derived from the cell wall is a matter that needs further study.

CONCLUSIONS

It is clear from my studies that, as Kohl also showed for certain orchids, in the floral organs of *Aspasia* sp. and *Oncidium stipitatum* the mucilage must originate in the protoplast, since the cytoplasm and the nucleus lie between it and the cell wall. In these forms mucilage cells were found in the young actively growing regions. This mucilage can hardly have the functions ascribed to that found in orchid pseudo-bulbs. In all forms investigated mucilage and raphides were found associated and neither was seen without the other.

The appearance of the nucleus and cytoplasm in the slime cell indicates that it is in a living and active condition. This is in sharp contrast to the description which has been given by Miss Stewart and others of the appearance of the nucleus and cytoplasm in the *Cactus* slime cells where the nucleus and cytoplasm are in a disorganized state.

In concluding I wish to express my gratitude to Dr. R. A. Harper, by whom these investigations were directed, for his assistance and illuminating suggestions.

BIBLIOGRAPHY

Wigand, A. Ueber die Desorganization der Pflanzenzelle, insbesondere über die physiologische Bedeutung von Gummi und Harz. Jahrb. Wiss. Bot. **3**: 115–182. *pl. 5–7.* 1863.

Frank, A. B. Ueber die anatomische Bedeutung und die Entstehung der vegetabilischen Schleime. Jahrb. Wiss. Bot. **5**: 161–200. *pl. 15, 16.* 1866.

Müller, N. J. C. Untersuchungen über die Vertheilung der Harze, ätherischen Oele, Gummi und Gummiharze, und die Stellung der Secretionsbehälter im Pflanzenkörper. Jahrb. Wiss. Bot. **5**: 387–439. *pl. 47–53.* 1867.

Hanstein, J. Über die Organe der Harz- und Schleim-Absonderung in den Laubknospen. Bot. Zeit. **26**: 697–713, 721–736, 745–761, 769–787. *pl. 11, 12.* 1868.

O'Sullivan, C. Researches on the gums of the arabin group. Part I. Arabic acid; its composition and the products of its decomposition. Jour. Chem. Soc. London **45**: 41–57. 1884.

Gardiner, W. On the physiological significance of water glands and nectaries. Proc. Cambridge Philos. Soc. **5**: 35–50. *pl. 1.* 1887.

Schimper, A. F. W. Über Kalkoxalatbildung in den Laubblättern. Bot. Zeit. **46**: 65–69, 81–89, 97–107, 113–123, 129–139, 145–153. 1888.

Stahl, E. Pflanzen und Schnecken. Jena. Zeitschr. Naturw. **22**: 557–635. 1888.

Gardiner, W., & Ito, T. On the structure of the mucilage secreting cells of *Blechnum occidentale*, L., and *Osmunda regalis*, L. Ann. Bot. **1**: 27–55. *pl. 3, 4.* 1888.

Tschirch, A. Angewandte Pflanzenanatomie. Berlin. 1889.

Kohl, F. G. Untersuchung der Kalksalze und Kieselsalze in Pflanze. Marburg. 1889.

Schimper, A. F. W. Zur Frage der Assimilation der Mineralsalze durch die grüne Pflanze. Flora **73**: 207–261. 1890.

Fluckiger, F. A. Pharmacognosie des Pflanzenreiches. Berlin. 1891.

Walliczek, H. Studien über die Membranschleime vegetativer Organe. Jahrb. Wiss. Bot. **25**: 209–277. *pl. 11–13.* 1893.

Groom, P. On bud-protection in dicotyledons. Trans. Linn. Soc. London, Bot. **3**: 255–266. *pl. 59, 60.* 1893.

Schilling, A. J. Anatomisch-biologische Untersuchungen über die Schleimbildung der Wasserpflanzen. Flora **78**: 280–360. *94 f.* 1894.

Groom, P. Preliminary notes on the relation between calcium and the conduction of carbohydrates in plants. Ann Bot. **10**: 91–96. 1896.

Kohl, F. G. Untersuchungeu über die Raphidenzellen. Bot. Centralbl. **79**: 273–282. *pl. 4, 5 + f. 1–6.* 1899.

Lewin, L. Ueber die toxicologische Stellung der Raphiden. Ber. Deutsch. Bot. Ges. **18**: 53–72. 1900.

O'Sullivan, C. Gum tragacanth. Proc. Chem. Soc. London **17**: 156, 157. 1901.

Guttenberg, H. von. Zur Entwickelungsgeschichte der Kristallzellen im Blatte von *Citrus.* Sitzungsb. Math.–Naturw. Cl. Akad. Wiss. Wien **111**^{1}: 855–872. *f. 1–15.* 1902.

Möbius, M. Über Raphiden in Epidermiszellen. Ber. Deutsch. Bot. Ges. **23**: 485–489. *1 f.* 1905.

Kraemer. H, Botany and Pharmocognosy. Ed. 3. Philadelphia & London. 1908.

Tschirch, A. Die Chemie und Biologie der pflanzlichen Sekrete. Leipzig. 1908.

Hare, R. F. Study of carbohydrates in the prickly pear and its fruits. Agr. Exp. Sta. New Mexico Coll. Bull. 80: 5–30. 1911.

Czapek, F. Biochemie der Pflanzen. Ed. 2. Jena. 1913.

Spoehr. A. H. The pentose sugars in plant metabolism. Plant World **20**: 365–379. 1917.

Faust, E. Resin secretion in *Balsamorrhiza sagittatta.* Bot. Gaz. **64**: 441–479. *pl. 28–31 + f. 1, 2.* 1917.

MacDougal, D. T., Richards, H. M., & Spoehr. H. A. Basis of succulence in plants. Bot. Gaz. **67**: 405–416. 1919.

Lloyd, F. The origin and nature of the mucilage in the cacti and in certain other plants. Am. Jour. Bot. **6**: 156–166. 1919.

Stewart, E. G. Mucilage or slime formation in the cacti. Bull. Torrey Club **46**: 157–166. *pl. 8.* 1919.

Bourquelot, E., & Bridel, M. Application de la methode biochimique a l'étude de plusieurs espèces d'orchidées indigènes. Decouverte d'un glucoside nouveau, la "loroglossine." Compt. Rend. Acad. Paris **68**: 701–703. 1919.

MacDougal, D. T. Hydration and growth. Carnegie Inst. Washington Publ. 297. 1920.

Czapek, F. Biochemie der Pflanzen. Ed. 2. Jena. 1921.

Explanation of plate 1

The figures were drawn with the aid of a camera lucida. With the exception of FIG. 4 all were drawn from paraffin sections of a young bud of *Aspasia* sp., which was fixed in Flemming s medium solution and stained with Flemming s triple stain. FIG. 4 was drawn from a free-hand section of fresh material stained with ruthenium red. Magnification of all except FIG. 4. × 1280.

FIG. 1. Hypertrophied cell with dense cytoplasm in which there is a suggestion of a vacuole. This cell, which will produce crystals and mucilage, is surrounded by smaller vegetative cells. The nuclei of two such cells are shown.

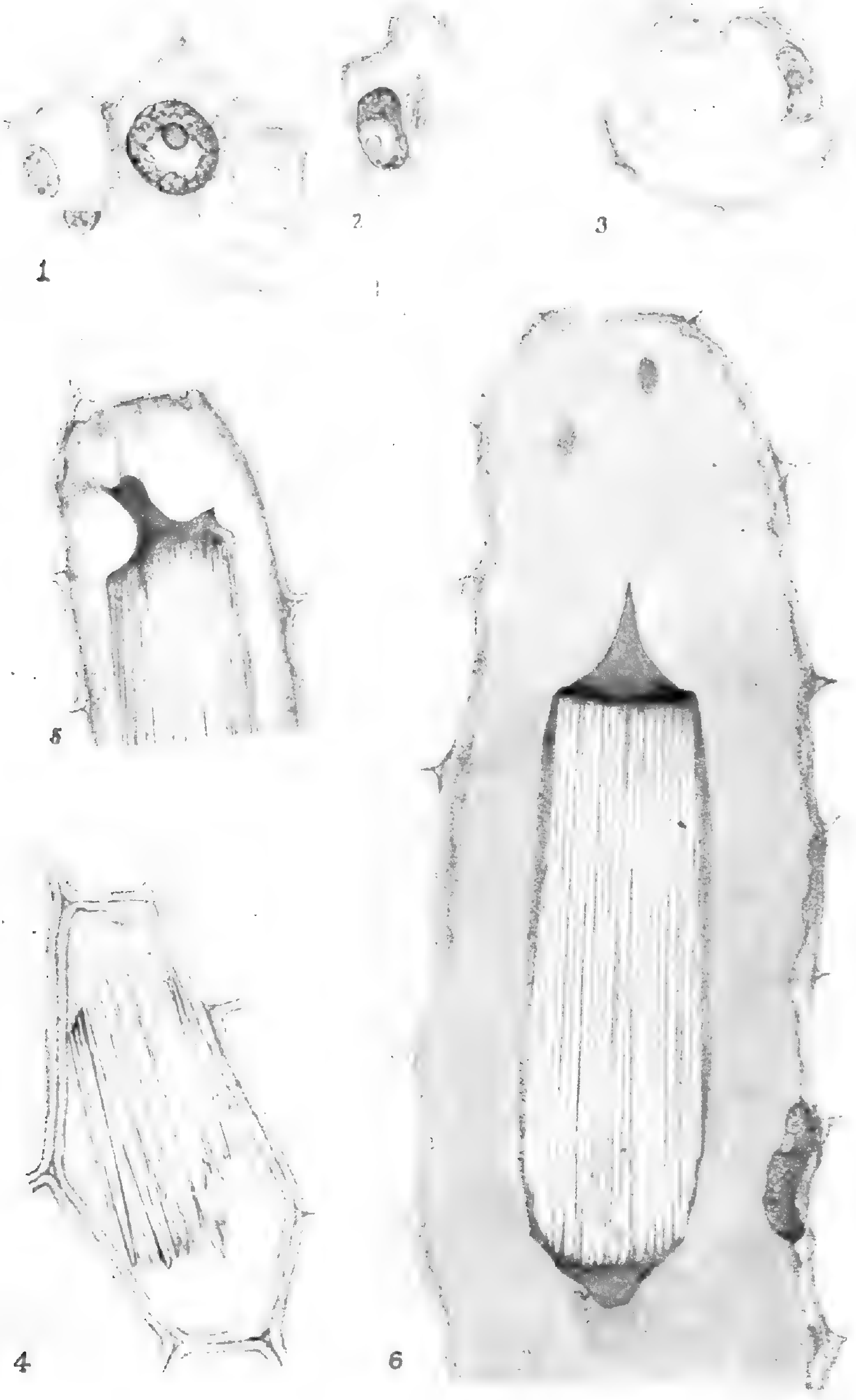
FIG. 2. Cell with enlarged crystals in a vacuole.

FIG. 3. Cross section of young mucilage cell showing nucleus with bundle of crystals in the center.

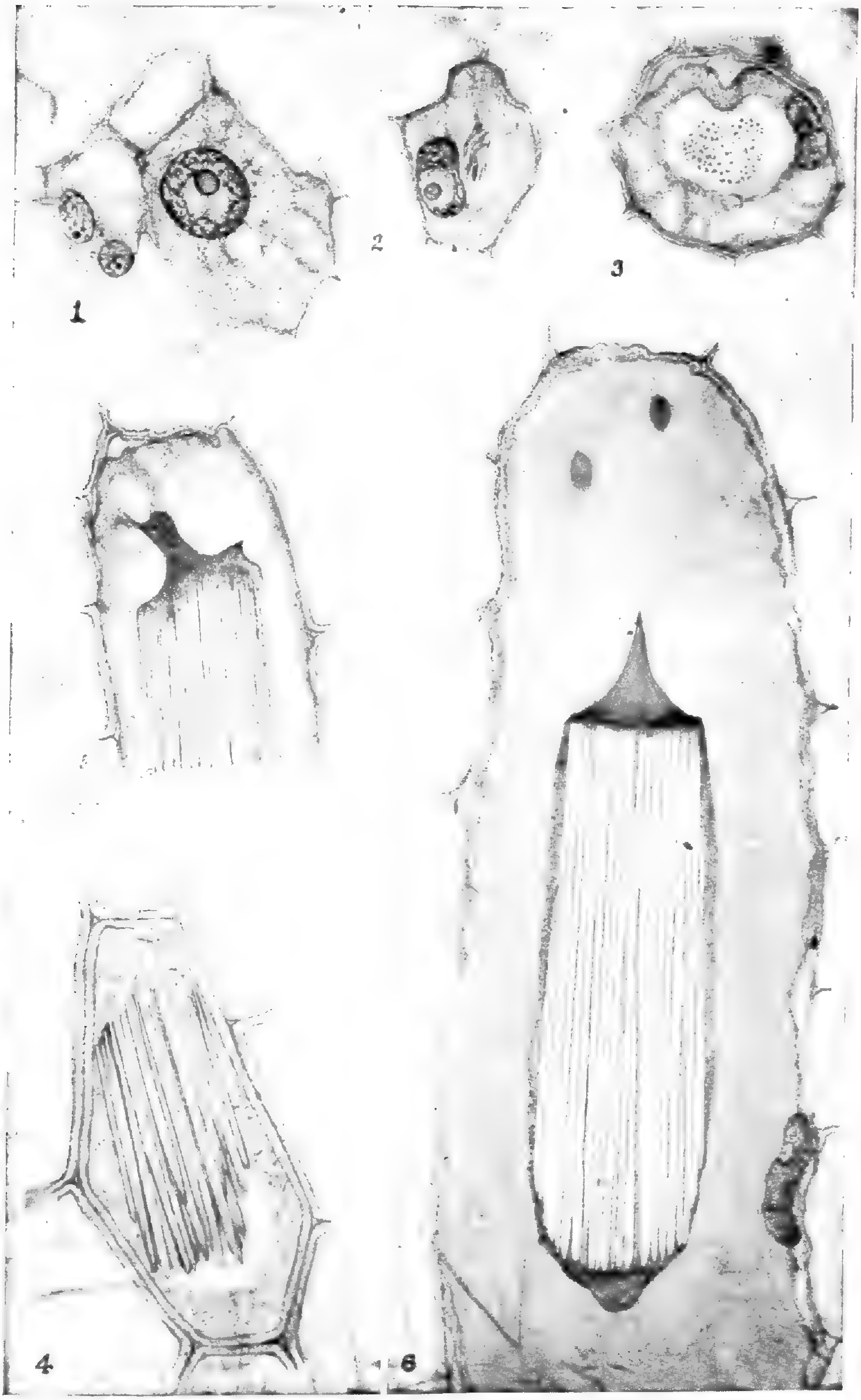
FIG. 4. Cell from a free-hand section of a mature flower stained with ruthenium red. The crystals are probably displaced by cutting. The middle lamella and thickness of the cell wall are clearly brought out with the ruthenium red. The cytoplasm does not yet show the homogeneous appearance of mucilage.

FIG. 5. Portion of a cell showing the sheath-like envelope around the bundle of crystals and its connection with primordial utricle of the cell.

FIG. 6. Portion of a mature mucilage cell showing a thin layer of cytoplasm between the mucilage and cell wall. In it an elongated deeply staining nucleus with nucleole is imbedded. The mucilage is stained a pale yellow the sheath around the crystals a bright red.



SMITH: HISTOLOGY OF ORCHIDS



SMITH: HISTOLOGY OF ORCHIDS

Apogamy in Phegopteris polypodioides*

ELIZABETH DOROTHY WUIST BROWN

(WITH TWENTY TEXT FIGURES)

INTRODUCTION

The wide-spread occurrence of apogamy in various genera of ferns has led to a great deal of investigation of the subject. In most of this study, however, greater emphasis has been laid upon the morphological and cytological than upon the physiological phase.

Leitgeb ('85), who was the first to study apogamy from this latter point of view, carried out a series of experiments to determine the light reactions of apogamous fern prothallia. Among the things he discovered was the fact that when prothallia of *Aspidium falcatum* bearing very young sporophytes were illuminated from the ventral side, the sporophytes were suppressed, new ones being formed on the dorsal side. In rare cases both dorsal and ventral sporophytes would survive and then they seemingly would give rise to a single sporophyte, with its various parts on both sides of the prothallium. Leitgeb considers the alterations of the light relations, during the growth of the prothallia, to be the probable cause of some of the modifications in the apogamous sporophytes described by DeBary ('78).

Bower ('88), although he did not make a physiological study of apogamy, calls attention to the importance of the environmental conditions in the life history of a fern. He cites the fact that the Hymenophyllaceae are exceedingly susceptible to changes of moisture in the air, and concludes that such changes react upon their mode of growth.

Lang ('98) found, in the case of nine different ferns, that by exposing the prothallia to direct sunlight and watering them from below, a condition favorable for vegetative growth but preventing fertilization, sporophytes were produced, although some of them were aborted.

Nathansohn ('00), experimenting with *Marsilia Drummondii*, concluded that exposure to higher temperature for a limited

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* Contribution from the Osborn Botanical Laboratory.

time stimulated the development of apogamous embryos in this species.

Woronin ('07) believes dryness to have been the cause of apogamy in the cultures of *Pellaea* and *Notholaena* with which she worked. By growing the prothallia of *Pellaea flavens* in poor light or on poor soil she was able to secure modifications in apogamous outgrowths, which showed transitions between gametophytes and sporophytes as varied as those described by Lang.

Yamanouchi ('08), in his study of *Nephrodium molle*, found that when conditions for fertilization were supplied this species reproduced normally, but that if the cultures were placed in strong light and watered from below fertilization was prevented and apogamous outgrowths were formed instead.

Outgrowths of an apogamous nature were described by Miss Pace ('10) as occurring on some unidentified prothallia which she kept well watered in bright light.

Heilbronn ('10), finding that dryness was not the cause of apogamy in the forms he studied, suggested that summer rather than winter cultures were more likely to become apogamous. But his investigations with different qualities and intensities of light, in moist cultures and at a high temperature, did not verify these conclusions.

Schlumberger ('11) found that by decreasing the moisture for old prothallia of *Woodsia ilvensis*, whose vitality had become lowered by the growth of algae and fungi in the cultures, the production of apogamous outgrowths was induced. He believes the observed enlargement of the apices of these apogamous outgrowths to be analogous to that described for *Anogramma chaerophylla* by Goebel ('97), who considered their development to be an adjustment on the part of the plant to the unfavorable environmental conditions caused by dryness.

Allen ('11) found apogamous sporophytes occurring on prothallia of *Aspidium falcatum* which had been grown in pots of red clay surrounded by sphagnum or moist sand, and kept either in a Wardian case or under bell jars for five, six, and in one case eleven months. These prothallia were not watered from above, the water in the sphagnum or sand keeping the clay uniformly moist.

Nagai ('14), describes cases of apogamy on prothallia of *Asplenium Nidus* grown on agar-agar and on filter paper saturated with nutrient solutions. These cultures were kept somewhat dry, in bright light, and at room temperature. The occurrence of apogamous sporophytes is also described on prothallia which, after growing on nitrogen- and phosphorus-free nutrient solution, had been transferred to sand saturated with nitrogen-free nutrient solution and left in bright light and at higher temperature. He does not attribute the development of these apogamous outgrowths to dryness but to unfavorable or unknown internal physiological conditions.

Stokey ('18) reports a case of apogamy in the genus *Dicksonia* and a few cases in the genus *Cyathea*. These occurred in cultures which had been exposed to rather intense light and grown on a medium of moist peat. While she does not consider dryness to be the determining factor, and while she does not state definitely that the intense light was the stimulus, she is of the opinion that the determining factor in one case of apogamy is not necessarily the determining one in another.

Steil ('18) found apogamy occurring in the genera *Pellaea*, *Pteris*, and *Aspidium*, in cultures on nutrient solution, sphagnum, nutrient agar, peat, clay, and loam, which were kept under bell jars in a Wardian case in the greenhouse. He does not consider the cultural conditions as the factor which induces apogamy in any of these cases.

MATERIAL

While collecting fern spores in and about Ithaca, New York, during the summer of 1915, my attention was called to a sporophyte of *Phegopteris polypodioides* Fée growing on a lawn in the city. It had been transplanted from its native habitat and did not appear normal or healthy, owing, doubtless, to the unfavorable conditions under which it was growing. As there was only one fertile frond, and this a small one, few spores were obtained. Cultures were made from these spores in the early fall upon Prantl's and Knop's full nutrient solutions and on certain modifications of these solutions. After the spores were sown the cultures were placed before an east window where conditions of light and temperature were approximately uniform for all. Once each week the prothallia were transferred to fresh nutrient solutions. About six months later, cases of apogamy were observed in cultures on Prantl's solution from which the NH_4NO_3 had been omitted. In view of the small number of such cases, however, it was thought best to repeat the experiments, and also to make cultures from spores of the same species whose sporophytes had grown under normal environmental conditions. In this way it was hoped that it might be possible, by a comparison of the results obtained, to determine whether apogamy was characteristic of this species, and, if so, under what environmental conditions this condition was induced.

For this purpose, during the following summer (1916), fresh spores were obtained from the same plant at Ithaca and also from wild plants at Brooklin, Maine (the latter through the courtesy of Dr. A. H. Graves). Cultures of these were started early in October on Prantl's and Knop's full nutrient solutions; on modifications of Prantl's solution from which NH_4NO_3, K_2SO_4, NaCl, $CaSO_4$, $MgSO_4$, Na_3PO_4, and both NaCl and Na_3PO_4, respectively, were omitted; and on Knop's solution minus the $Ca(NO_3)_2$. In preparing the cultures, about 25 cc. of the nutrient medium was poured into a small glass dish, a drop of a 1 per cent solution of ferric chloride added, and the spores sown upon the surface of the solution. The dishes were covered with loose-fitting glass tops. Two series of cultures were prepared from each of the two lots of spores, one of which was placed in the greenhouse in bright light, the other in the laboratory before an east window. The germinating prothallia, instead of being transferred at intervals to fresh solutions (as had been done the preceding year) were allowed to remain upon the original solution on which the spores were sown, and the increasingly unfavorable conditions of environment which thus resulted were further enhanced by a luxuriant growth of algae which developed in all the dishes.

DEVELOPMENT OF THE PROTHALLIA

Practically no difference was noted in the germination of the spores or in the early development of the prothallia from the two sources. Germination began in about one week after the spores were sown. The early growth and development of the prothallia was rapid in all the cultures, but later it varied according to the particular solution upon which they were growing.

In the case of the cultures which were kept in the greenhouse, the majority of the prothallia growing on the modified Prantl's and Knop's solutions did not develop beyond a filamentous stage and lived only from five to six weeks. This behavior was attributed to temperature rather than light: the temperature in the greenhouse being very high during the greater part of the day, the culture media became overheated, with the result that the prothallia, lacking in vigor on account of an insufficient supply of some essential element in the nutrient solution, were unable to withstand the unfavorable conditions of temperature. A few prothallia in the greenhouse cultures on Prantl's and Knop's unmodified solutions survived, however, and developed into normal heart-shaped thalli.

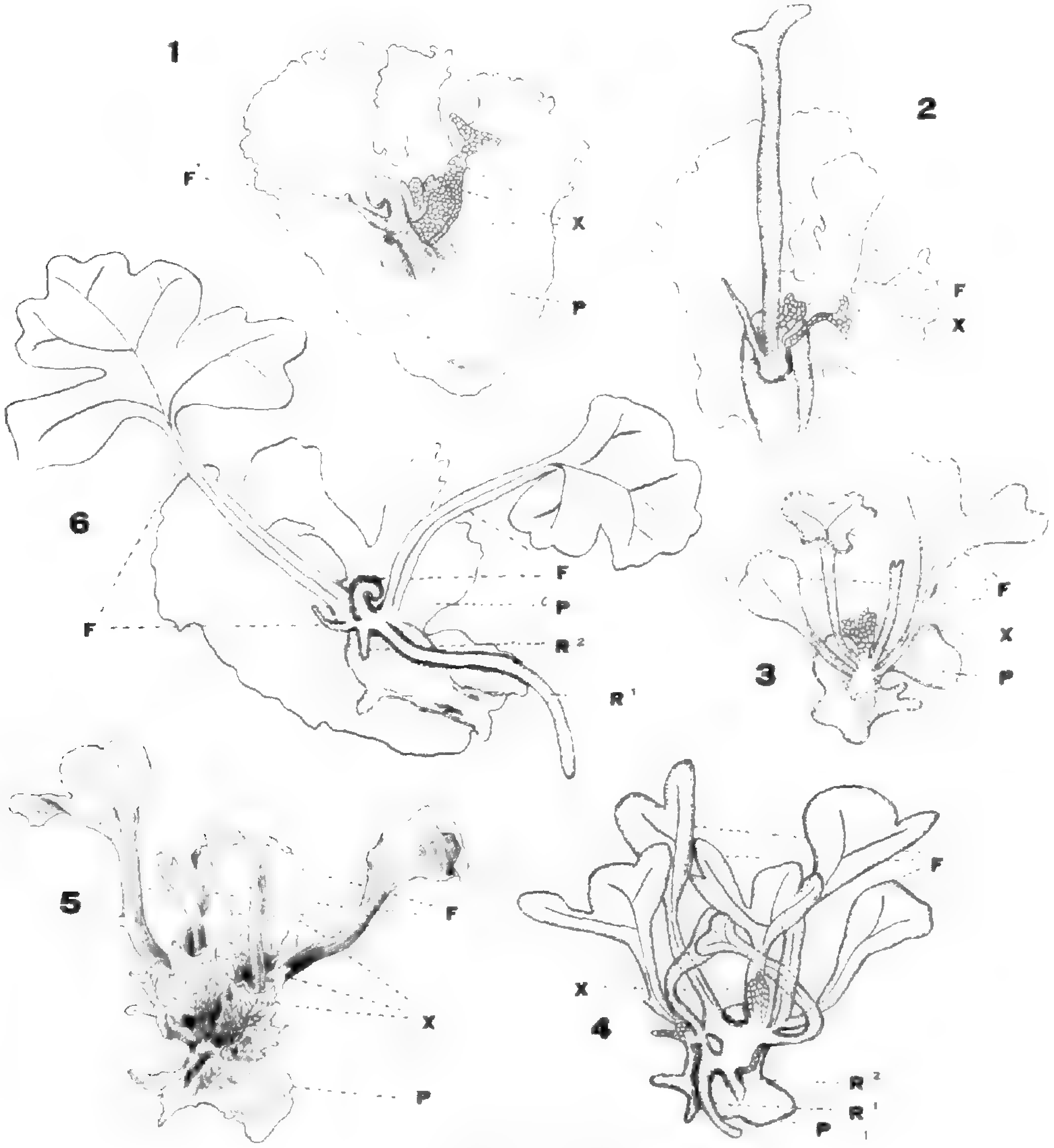
The length attained by the prothallium during its filamentous stage varied greatly, but even in cultures on the full nutrient solutions it was not uncommon to find prothallia with filaments of seven and eight cells in length. These usually occurred in crowded regions of the cultures. In the cultures on the modified solutions the length of the filaments was even greater, some having as many as twelve to fifteen cells. The length of the cells also varied, some being long and others short, but with the long cells predominating. It is customary for the length of the filament of the prothallia of any species of ferns to vary under unfavorable environmental conditions, but the range of variability in length seems fixed for each species. In this respect *Phegopteris polypodioides* showed the greatest range of variability of any prothallia of the Polypodiaceae that have come under the author's observation.

Branching was exceedingly varied and occurred frequently in the cultures on the modified solutions, while on the unmodified solutions it was not uncommon. Many times the first cell of the filament, instead of dividing transversely, divided lengthwise, giving rise to two distinct filaments, which later broadened into prothallia. Sometimes other cells of the filaments divided, giving rise to branches which in turn broadened into prothallia. In other cases a filament of three cells was first formed, and then the first and second cells of the filament divided lengthwise, giving rise to side branches. These side branches continued their growth as filaments for a time, and then branched dichotomously. In still other cases the end cell of a filament of four cells elongated transversely instead of longitudinally and divided crosswise, giving rise to two distinct branches which in turn branched. Some of these branches, after broadening into filaments of two cells in width, reverted to a one-cell stage. Again a short filament was formed, which broadened out, and then, from this broadened region side branches were formed; the cells of the apical margin of the broadened portion also gave rise to branches which in turn formed other branches. Some of these branches, after forming either a long filament or a short one of only three cells, broadened into a prothallium bearing antheridia, after which it reverted to a filamentous condition. This capacity of the prothallia to branch extensively seems to be of advantage to the plant in enabling it to meet unfavorable environmental conditions, by increasing the number of prothallia, thus giving rise to an extended area of rhizoids, as well as insuring the formation of a larger number of sporophytes, either normally or apogamously. Atkinson designates the branched prothallia of *Adiantum cuneatum* described by him as "starved prothallia," and the author ('16) has shown that branching in various prothallia of the Polypodiaceae is intimately associated with conditions of nutrition, poor nutritive conditions accelerating the stimulus for branching and good nutritive conditions weakening it. Another interesting feature in connection with the development of the young prothallia in the modified solutions was the frequency with which they met the unfavorable conditions for nourishment by reversion to a filamentous condition. Prothallia several cells in width and bearing antheridia would revert to a filamentous condition; then, after forming a filament three to eleven cells in length, they would broaden again to form a prothallium which in turn bore antheridia. Goebel considers a reversion to a juvenile form to be the result of unfavorable conditions, which in this case was doubtless an insufficient food supply.

In the cultures which were kept in the laboratory, sexual organs, both male and female, developed on the prothallia in all the solutions, both modified and unmodified. They also developed on the few prothalia which survived on the unmodified solutions in the greenhouse cultures. Antheridia appeared in four to six weeks after the spores were sown. Both monoecious and dioecious prothallia occurred in the laboratory cultures on the unmodified Prantl's and Knop's solutions, while only dioecious prothallia were observed in the greenhouse cultures on the same solutions. In the younger cultures, those not more than six or eight weeks old, the majority of the prothallia were dioecious, the percentage of monoecious individuals being very low even in cultures on the modified solutions. Among older prothallia it was not infrequent to find monoecious specimens, the antheridia developing on or near the margin of the larger heart-shaped prothallia. Antheridia were never observed on the cushion, among the archegonia, as is the case in typical monoecious prothallia. The percentage of male prothallia was much higher than that of female, as is usually the case on the modified solutions. While many of the male prothallia were mere filaments of from one to three cells in width bearing antheridia, there were also a large number of small irregularly-shaped cell-plates one cell in thickness, bearing antheridia over both the upper and lower surfaces. The antherozoids in all the cultures appeared normal. The majority of the larger prothallia on the modifiedsolutions were more or less heart-shaped, without a sinus but with a well-developed meristem upon which archegonia were formed. Evidently these were not functional, as no normal sporophytes developed. In rare cases a few antheridia were formed from the marginal cells of the prothallia which developed the apogamous outgrowths and sporophytes.

DESCRIPTION OF THF APOGAMOUS OUTGROWTHS AND SPOROPHYTES

In the first observed cases of apogamy the prothallia bearing the apogamous sporophytes were irregularly heart-shaped, with a well-developed meristem. Archegonia were formed on some of the prothallia, but not antheridia. The apogamous sporophytes, in all these cases, originated as slight swellings of the archegonial cushion, either on the dorsal or ventral side, at some point near the notch or at the center of the cushion. These swellings gradually increased in size until dome-shaped cellular masses were formed, from which the parts of the apogamous sporophytes appeared in the following order: leaf or leaves, root, and stem. No foot was formed. In some cases proliferations, either filamentous or slightly expanded at the apices, developed from the cellular mass. Also, multicellular hairs or outgrowths frequently formed at the base of the first leaf or leaves of the young sporophytes. FIGS. 1–4 show the development of one of these apogamous sporophytes. In this case the prothallium was lobed and the apogamous sporophyte developed at the center of the cushion as a cellular mass (FIG. 1).



FIGS. 1-6

From this cellular mass, seven normal leaves were developed before a root was formed. Soon after the first root formed, another began to develop (FIG. 4). Meanwhile the old prothallium became greatly reduced in size. The subsequent growth of the apogamous sporophyte was normal and rapid. FIGS. 5 and 6 represent other examples of apogamous sporophytes.

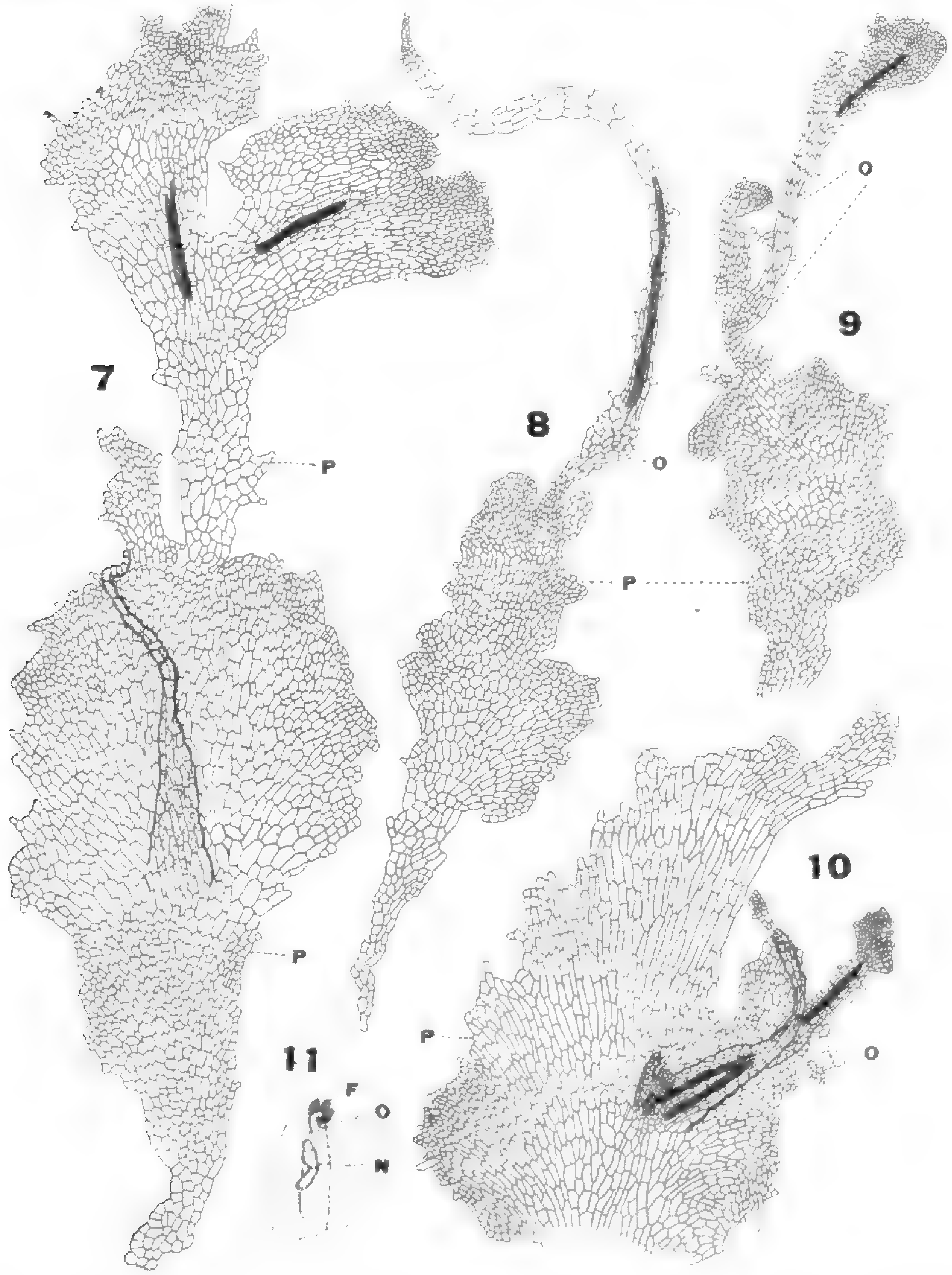
In the experiments of the second year apogamous outgrowths were first observed in the laboratory cultures on Knop's full solution about four to six months after sowing. Subsequently they developed in essentially all the cultures. These outgrowths were very diversified in form, and while some originated as cellular masses, at various places on the archegonial cushion, the majority developed as outgrowths of the prothallia in the region where the sinus usually occurs. It was only in rare cases that sexual organs, either antheridia or archegonia, formed on the prothallia bearing apogamous outgrowths.

FIG. 7 shows an apparently normal and slightly elongated prothallium with a broad lobed apex. No sexual organs developed, although a well-developed archegonial cushion was present. From the region of the sinus a lobe formed. Narrow at first, it gradually widened and then branched to form two prothallia with broad apices, each having a sinus. In the thickened central region of each of these branch-prothallia a cluster of tracheids appeared. In the meantime, from the center of the archegonial cushion of the original prothallium a cellular mass began to form. This continued to grow as a thick conical mass.

The apogamous outgrowth shown in FIG. 8 formed as a lobe from the sinus of a very irregular, elongated prothallium whose apex was lobed. This lobe, which later became an apogamous sporophyte, was at first one cell in thickness and several cells in width. It broadened and thickened into a bulbous cellular mass, then elongated and formed a series of tracheids in the center. Finally it reverted to a filament one cell in thickness.

FIG. 9 shows an apogamous outgrowth which originated as a lobe from the irregular apex, a little to one side of the center of an elongated prothallium. This lobe broadened and thickened, forming two branches. One branch did not develop as rapidly as the other and appeared more thallus-like, being only one cell in thickness. The other branch, after elongating slightly, broadened into a prothallium thickened at the center and with a heart-shaped apex. Tracheids formed in this thickened area and a small branch developed at one side of the prothallium near the apex.

The apogamous sporophyte shown in FIG. 10 developed first as a cellular mass on the meristem near the sinus of a very irregular-shaped old prothallium whose basal portion had died. The apex of this prothallium was strongly indented, the sinus being situated slightly to one side of the middle. From one side of the prothallium a very much branched proliferation developed, while from the cellular mass outgrowths resembling somewhat the normal leaves of young sporophytes were formed.



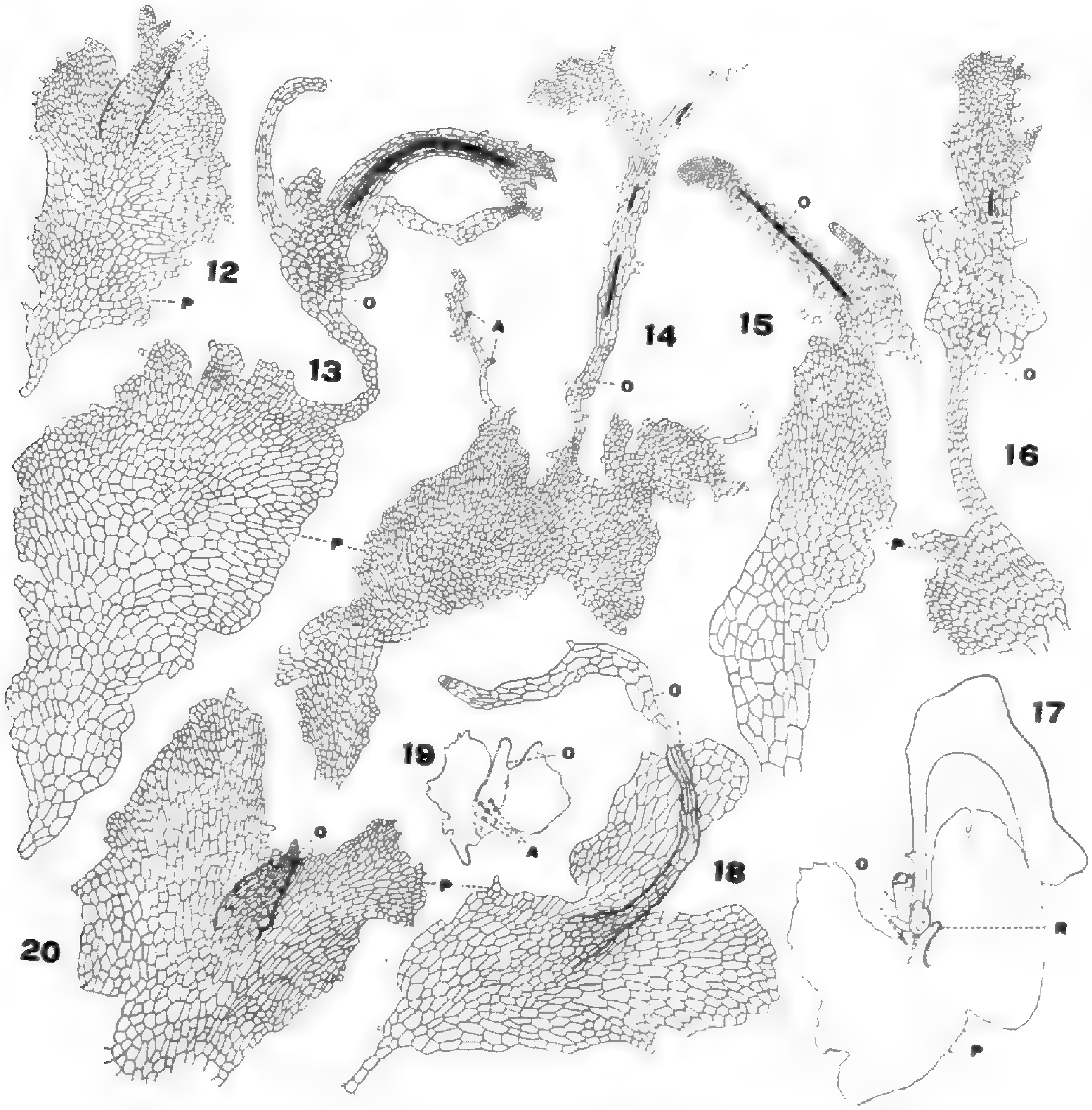
FIGS. 7–11

The first outgrowth, after forming an elongated flat structure several cells in thickness and width, broadened into a prothallium with a slight sinus. Tracheids formed in the thickened region at the center. The second outgrowth continued its development as an elongated, thick, club-shaped structure bearing tracheids near the base. The third outgrowth at a very early stage formed a slightly elongated prothallus-like structure, distinctly notched and bearing a series of very short tracheids in the elongated portion.

On the very irregular prothallium shown in FIG. 11 a normal embryo was formed near the base of the archegonial cushion, while near the sinus an apogamous sporophyte developed. This appeared as a cellular mass surrounded by proliferations, from which the first leaf was formed.

Of the apogamous outgrowths represented by FIGS 12–20, those of FIGS. 12, 16–18, and 20 originated as cellular masses on the archegonial cushion of the prothallia; those of FIGS. 13–15 originated as lobes from the margins of the prothallia and that of FIG. 19 as a lobe in the sinus. The cells in most of these marginal lobes were large. The prothallium shown in FIG. 13 was somewhat elongated and bore many lobes on the margin of its apex. One of these lobes, after elongating into a prothallus-like structure, several cells in width and one cell in thickness, formed a cellular mass. From this were given off three branches. The development of the apogamous outgrowth was continued by a reversion to a broad thick prothallium with a lobed apex. A series of tracheids were formed in the thickened region of this outgrowth. All the branches given off by the cellular mass were curled after the manner of a normal leaf, in the early stages of their development, and one resembled a normal leaf in shape. However, this was the extent of the similarity between these branches and normal sporophytic leaves. The branches were only one cell in thickness and no tracheids were present.

The apogamous outgrowth shown by FIG. 14 occurred as a lobe on the margin of a very irregular and distinctly notched prothallium, in the region of the sinus. From only a few cells in width the apogamous outgrowth developed into an elongated prothallus-like structure, thickened in the center and branched at its apex. One of these branches was narrow and several cells in thickness, while the other was wider, only one cell in thickness, and with a broad notched apex. Series of short tracheids were formed in both the thickened region of the elongated portion of the sporophyte and on its branch. Another outgrowth, prothallus-like in form, developed from the margin of one wing of the prothallium and bore on its margin an antheridium.



FIGS. 12–20

FIG. 15 shows an apogamous outgrowth which developed by the narrowing and lengthening of the apex of a prothallium one cell in thickness. It soon branched, one branch being very irregular in form and only one cell in thickness. while the other was elongated and several cells in thickness in the central region where it bore a group of long tracheids. A small side branch was given off from the apogamous outgrowth.

The prothallium, upon which the apogamous outgrowth formed as a lobe in the sinus, was irregularly heart-shaped and bore archegonia on a well-developed meristem (FIG. 19).

With the exception on the one shown in FIG. 16, all the prothallia upon which apogamous outgrowths originated as cellular masses on the archegonial cushion were distinctly notched, and the apogamous outgrowths first appeared as conical cellular masses, the apices of some being more pointed than others. However, the outgrowth shown in FIG. 18 varied somewhat in its development. Beginning as a cellular mass, it formed an elongated, slightly flattened and thickened prothallus-like structure, which in turn reverted to a filamentous condition.

The apogamous sporophyte shown by FIG. 17 began its development as a cellular mass near the sinus on the archegonial cushion of an irregularly shaped prothallium. From this mass there developed first two structures intermediate between leaves and prothallia and then a root. The first of these intermediate structures resembled a very much elongated prothallium one cell in thickness with an expanded and irregularly lobed apex. The second was curled at first in the same way as a normal leaf but resembled the first in being an elongated prothallus like structure one cell in thickness. The root appeared normal.

DISCUSSION

The factors which are considered as the possible controlling or influencing ones in apogamy, as advanced by the previously mentioned workers, are the following: (1) insufficient water for fertilization, (2) weak light, (3) bright light, (4) high temperature, (5) poor soil. In the opinion of five of the writers cited, lack of sufficient water to permit fertilization to take place is regarded as the controlling factor in the particular ferns with which they worked. In the case of *Phegopteris polypodioides*, as well as in the other cases of apogamy previously described by the author ('19, '20), this factor can be entirely eliminated, since the prothallia were grown upon a liquid medium.

Also the factor of light, either bright or weak, can not be considered as the most important one in these cases of apogamy for the following reasons. (1) All cultures were kept under light conditions which not only proved sufficient for the production of normal sporophytes but which failed to retard their development in those cultures of the full solutions which were renewed frequently. (2) In cases where apogamous prothallia from a nutrient solution with one of the essential elements omitted were transferred to a fresh full nutrient solution, thereby permitting the vitality of the prothallia to be renewed, no more apogamous outgrowths or sporophytes were formed, although the cultures were kept under the same light and temperature conditions. In some cases normal sporophytes developed. The formation of these normal sporophytes ceased as soon as the new solution was exhausted and the vitality of the prothallia thereby lowered. (3) Some of the prothallia which had developed upon a full nutrient solution, when removed to a solution from which some essential element was omitted, produced apogamous outgrowths or sporophytes as soon as their vitality was reduced. However, relatively few were formed under these conditions because the prothallia of *Phegopteris polypodioides*, when grown from the spores upon a full nutrient solution which afforded the necessary elements for growth and development, were unable to adjust themselves readily to the physiological action of an incomplete solution. The vitality of the prothallia seemed to be lowered so quickly that it was impossible for them to make an attempt to overcome the unfavorable condition for reproduction by producing apogamous outgrowths and sporophytes. The prothallia of various species of ferns seem to differ in this respect, some being more sensitive, while others are more tolerant. (4) Apogamous prothallia occurred frequently in uncrowded regions of the cultures where light conditions were very good, while on the other hand in the cultures of the full solutions normal sporophytes developed in the most crowded regions where the light condition was the poorest.

The factor of temperature can not be considered as the controlling factor in apogamy in *Phegopteris polypodioides*. The prothallia in all cultures, both those which produced normal sporophytes when the food supply was sufficient and those which produced apogamous ones when the food supply was insufficient, were kept under the same temperature conditions.

Poor soil as a factor in causing apogamy would be operative either through the absence of the elements necessary for development or the presence of those elements in such a form as not to be available for the use of the prothallia. In either case it would be a lack of sufficient nourishment which would be the stimulus to apogamy. The results secured on poor soil would compare with those obtained in *Phegopteris polypodioides* where the apogamous outgrowths and sporophytes were due to insufficient nourishment. The proof for this is the fact that no cases of apogamy were observed in cultures of the full nutrient solution when it was renewed frequently; or, in other words, when a sufficient food supply was available. Also, apogamous outgrowths and sporophytes ceased to develop, and in some cases normal sporophytes were formed, when the nutrient solutions were renewed in the cultures, although other factors remained the same. Still further evidence is the fact that frequently the apogamous outgrowths showed a reversion from a more or less complex structure, several cells in thickness, bearing tracheids to a simple prothallus-like body only one cell in thickness and branched, indicating a still greater lowering of the vitality, which was doubtless due to an insufficient food supply.

Prantl's ('81) work on the nutrition of ferns, Klebs's ('93) valuable studies on the physiology of reproduction, and the work of others have demonstrated that an intimate connection exists between nutrition and growth, and between growth and reproduction. Since both growth and reproduction are dependent upon nutrition, it would seem as if nutrition was the most important if not the controlling factor in causing apogamy. Farmer and Digby ('07), Winkler ('08), Allen ('11), and others are of the opinion that the morphological characters of the gametophyte and sporophyte are not determined by the chromosome numbers as such. It would seem as if the morphological features were determined to a large extent by physiological characteristics, and that the difference between the gametophytic and sporophytic tissue was not a marked one physiologically. Apogamy seems to be due in all cases to a lowering of the vitality of the prothallia to such an extent that normal sporophytes can not be formed. This may be brought about by one or more factors working separately or together. Therefore, apogamy may be regarded, as Bower ('88) has considered it, as a simplification of the life cycle of the fern, or, in other words, as a response to the changed environmental conditions for which a modified life cycle is an advantage to the plant. Doubtless the prothallia of all species of ferns possess this latent quality by virtue of which they can respond to changed environmental conditions by a reversion to this simplified life cycle, which was probably the more primitive.

For this and other reasons the value of the physiological study of the gametophytes of ferns can hardly be overestimated from the standpoint of determining the cause or causes of apogamy and as shedding light upon the physiological problems connected with the interpretation of sexual phenomena and the expression of the individuality of plants in their relation to their environment. The latter point should be emphasized especially, for it is not of so much importance that we determine the exact factor of the environment, which works separately or together with other factors in causing apogamy, as that stress be laid on the individual physiological characteristics of the gametophyte and sporophyte which cause them to respond to the stimulus of the particular situation in the way best adapted to meet their requirements. On account of these individual physiological characterisctics of the gametophyte the same factor or group of factors need not be the cause of apogamy in all species of ferns.

The fact that apogamy occurred frequently in *Phegopteris polypodioides* under cultural conditions unfavorable for nourishment would seem to indicate that apogamy is not a rare occurrence in this species and that it is easily induced.

SUMMARY

1. The filamentous stage of the prothallia of *Phegopteris polypodioides*, grown upon unmodified and modified Prantl's and Knop's solutions, showed a great range of variability in length, the greatest length occurring in the modified solutions.

2. Branching of the prothallia and reversion to a filamentous condition occurred frequently under unfavorable cultural conditions.

3. Sexual organs, both male and female, developed on the prothallia in cultures of the unmodified solutions which were

kept in the laboratory. The percentage of male prothallia was much higher in cultures on the modified solutions, while on the unmodified solutions female prothallia predominated.

4. Both monecious and dioecious prothallia occurred in all the cultures, but the percentage of monoecious prothallia was low, even in young cultures on the modified solutions.

5. Apogamous sporophytes were observed in cultures on Prantl's solution with NH_4NO_3 omitted.

6. Apogamous outgrowths and structures intermediate between mere outgrowths and apogamous sporophytes were observed in cultures on the Knop's full nutrient solution.

LITERATURE CITED

Allen, R. F. (1911). Studies in spermatogenesis and apogamy in ferns. Trans. Wisconsin Acad. **17:** 1–56. *pl. 1–6.*

Atkinson, G. F. (1894). The study of the biology of ferns by the collodion method. New York.

Bary, A. de (1878). Ueber apogame Farne und die Erscheinung der Apogamie im Allgemeinen. Bot. Zeit. **36:** 449–487. *pl. 14.*

Bower, F. O. (1888). On some normal and abnormal developments of the aöphyte in *Trichomanes.* Ann. Bot. **1:** 269–305. *pl. 14–16.*

Brown, E. Wuist. (1919). Apogamy in *Camptosorus rhizophyllus.* Bull. Torrey Club **46:** 27–30. *pl. 2.*

——— (1920). Apogamy in *Osmunda cinnamomea* and *O. Claytoniana.* Bull. Torrey Club **47:** 339–345. *f. 1–7.*

Farmer, J. B., & Digby, L. (1907). Studies in apospory and apogamy in ferns. Ann. Bot. **21:** 161–199. *pl. 16–20.*

Goebel, K. (1900). Organography of plants. English translation. Oxford.

Heilbronn, A. (1910). Apogamie, Bastardierung und Erblichkeitsverhältnisse bei einigen Farnen. Flora **101:** 1–42. *f. 1–43.*

Klebs, G. (1893). Ueber den Einfluss des Lichtes auf die Fortpflanzung der Gewächse. Biol. Centralbl. **13:** 641–656.

Lang, W. H. (1898). On apogamy and the development of sporangia upon fern prothallia. Phil. Trans. Roy. Soc. **190B:** 187–239. *pl. 7–11.*

Leitgeb, H. (1885). Die Sprossbildnung an apogamen Farnprothallien. Ber Deutsch. Bot. Gesells. **3**: 169–176.

Nagai, I. (1914). Physiologische Untersuchungen über Fernprothallien. Flora **106**: 281–330. *f. 1–18.*

Nathansohn, A. (1900). Ueber Parthenogensis bei *Marsilia* und ihre Abhängigkeit von der Temperatur. Ber Deutsch. Bot. Gesells. **18**: 99–109.

Pace, L. (1910). Some peculiar fern prothallia. Bot. Gaz. **50**: 49–58. *f. 1–11.*

Prantl, K. (1881). Beobachtung über die Ernährung der Farnprothallien und die Vertheilung der Sexualorgane. Bot. Zeit. **39**: 753–758, 770–776.

Schlumberger, O. (1911). Familienmerkmale der Cyatheaceen und Polypodiaceen und die Beziehungen der Gattung *Woodsia* und verwandter Arten zu beiden Familien. Flora **102**: 383–414. *f. 1–15.*

Steil, W. H. (1911). Apogamy in *Pellaea atropurpurea*. Bot. Gaz. **52**: 400–401.

——— ——— (1915, a). Apogamy in *Nephrodium hertipes*. Bot. Gaz. **59**: 254, 255.

——— ——— (1915, b). Some new cases of apogamy in ferns. Preliminary note. Science II. **41**: 293–294.

——— ——— (1918). Studies of some new cases of apogamy in ferns. Bull Torrey Club **45**: 93–108. *pl. 4, 5.*

Stokey, A. (1918). Apogamy in the Cyatheaceae. Bot. Gaz. **65**: 97–102. *f. 1–10.*

Winkler, H. (1908). Parthenogenesis und Apogamie im Pflanzenreich. Prog. Rei Bot. **2**^{3}: 1–66. *f. 1–14.*

Woronin, H. (1907). Apogamie und Aposporie bei einigen Farnen. Flora **98**: 101–162. *f. 1–72.*

Wuist, E. D. (1916). Branched prothallia in the Polypodiaceae Bull. Torrey Club **43**: 365–383. *f. 1–15.*

Yamanouchi, S. (1908). Apogamy in *Nephrodium*. Bot. Gaz. **45**: 289–318. *pl. 9, 10 + f. 1–3.*

Studies of West Indian plants---XI

NATHANIEL LORD BRITTON

64. UNDESCRIBED SPECIES FROM CUBA

Juniperus saxicola Britton & Wilson, sp. nov.

A densely branched small tree, 3–8 m. high. Leaves all subulate-acicular, subimbricate, somewhat spreading, 4–7 mm. long, about 1 mm. broad at the base, lustrous; fruit blue, broadly ellipsoid or subglobose, 5 mm. long, 3–4 mm. in diameter.

On rocks, crest of Sierra Maestra, Oriente (*Léon 10798*, type); also collected on Farallones de Regino, Estribo Turquino (*Léon 11024*).

Myrica cacuminis Britton & Wilson, sp. nov.

A shrub, 3–4 m. high, much branched, the slender twigs densely pilose. Leaves elliptic to suborbicular, 7–18 mm. long, short-petioled, sharply few-toothed or entire, coriaceous, pinnately few-veined, pubescent on both sides, the apex rounded, the base rounded or obtuse; flowers and fruit not seen.

Pico Turquino, Oriente (*Léon 10973*, type; *Bucher 19*).

Pilea ovalifolia Britton & Wilson, sp. nov.

Stems creeping, rather stout, rooting at the nodes. Leaves chartaceous, elliptic, obtuse or rounded at the apex, rather coarsely crenate, pinnately 3-nerved, glabrous, those of each pair often unequal in size; larger leaves up to 5.5 cm. long, 3.4 cm. wide, with petioles 1.5–3 cm. long; smaller leaves 2.5–4 cm. long, 1.5–2.6 cm. wide, the petioles 1–2 cm. long; upper leaf-surface densely covered with minute linear raphides, the lower surface papillose; pistillate inflorescence longer than the leaves, peduncled, its branches spreading; achenes ovate, about 0.9 mm. long.

Sierra Maestra, Oriente (*Léon 10767*).

Pilea membranacea Britton & Wilson, sp. nov.

Stem slender, puberulent. Leaves membranous, lanceolate to ovate, acuminate, coarsely toothed, 3-nerved, glabrous, those of each pair unequal in size; larger leaves up to 5 cm. long, 1.8 cm. wide, with slender petioles 0.7–1 cm. long; smaller leaves 1–2 cm. long, 0.6–1 cm. wide, the petioles 2–4 mm. long; upper leaf-surfaces covered with minute white linear raphids, those of the lower surface rather inconspicuous; pistillate inflorescence slender, longer than the leaves; achenes elliptic, 1 mm. long.

Sierra Maestra, Oriente (*Léon 10815*).

Pilea micromeriaefolia Britton & Wilson, sp. nov.

Stems elongate, woody, procumbent, the branches erect or ascending, 4-angled, scaly encrusted. Leaves in whorls of 3's or 4's, lanceolate, 0.8–1 cm. long, about 2 mm. wide, acute at the apex, obtuse at the base, glabrous, the petioles 1 mm. long or less; upper leaf-surfaces covered with linear raphides, those on the lower surface coarser; inflorescence not seen.

Brecha de Regino, Estribo Turquino, Oriente (*Léon 11008*).

Pilea yarensis Britton & Wilson, sp. nov.

An erect monoecious herb, 2–3.5 dm. high. Leaves membranous, broadly elliptic, acuminate at the apex, acute at the base, crenate-dentate, 3-nerved, glabrous above, often slightly pubescent on the midvein beneath, those of each pair unequal in size; larger leaves up to 15 cm. long, 6 cm. wide, with slender petioles sometimes 3.5 cm. long; smaller leaves up to 11 cm. long, 5 cm. wide, with petioles 1–2 cm. long; upper leaf-surface papillose, densely covered with linear raphides, those of the lower surface often indistinct; staminate inflorescence equalling or longer than the leaves, the peduncles sometimes 1 dm. long, the branches spreading, the perianth about 1.5 mm. long; pistillate inflorescence equalling or shorter than the leaves; achenes elliptic, 0.8 mm. long.

Bank of the Yara River, Sierra Maestra, Oriente (*Léon 10736*).

Pilea ermitensis Britton, sp. nov.

Stems slender, densely covered with linear raphides. Leaves oblong, oblong-lanceolate or elliptic, membranous, acute, entire, 3-nerved, glabrous, those of each pair unequal in size; larger leaves up to 3 cm. long, 6–7 mm. wide, with petioles 3 mm. long; smaller leaves 1–1.7 cm. long, 4–5 mm. wide, the petioles short; raphides of the upper leaf-surface minute, linear-filiform, those of the lower surface scattered, more conspicuous and stouter; inflorescence often shorter than the petioles, the flowers borne in globose heads 1.5–2 mm. in diameter; achenes elliptic-ovate, about 0.5 mm. long.

La Ermita, Oriente (*Hioram 4921*).

Pilea crenata Britton & Wilson, sp. nov.

Stem creeping, often rooting at the nodes, the branches erect or ascending, pilose. Leaves chartaceous, oval to suborbicular, rounded at the apex, rounded or acute at the base, crenulate, 3-nerved, glabroùs above, pilose on the nerves beneath, those of each pair often unequal in size; larger leaves up to 3 cm. long, 2.5 cm. wide, with slender petioles 1.5–2 cm. long; smaller leaves 1–2 cm. long, 1–2 cm. wide, the petioles 0.7–1 cm. long; upper and lower leaf-surfaces densely covered with linear raphides; pistillate inflorescence as long as or shorter than the leaves; achenes about 0.6 mm. long.

Sierra Maestra, Oriente (*Léon 10766*, type; *Léon, Clement and Roca 9872*).

Coccolobis monticola Britton, sp. nov.

Branches slender, glabrous; young twigs pubescent. Ocreae cylindric, 1 cm. long or less; leaves coriaceous, light green, 3–6 cm. long, reticulate-veined on both sides, shining above, dull and black-dotted beneath, the apex acute, the base obliquely obtuse, the petioles about 2 mm. long; racemes very slender, glabrous, densely many-flowered; ocreolae subtruncate, about 0.5 mm. long; pedicels glabrous, about 1 mm. long; calyx about 1 mm. long.

Sierra Maestra, Oriente (*Léon 10713*).

Coccolobis saxicola Britton, sp. nov.

A shrub about 3 m. high, glabrous throughout, the twigs short, stout, more or less tortuous. Ocreae subtruncate, 4–6 mm. long; leaves coriaceous, elliptic to obovate, 9 cm. long or less, the veins somewhat impressed above, prominent beneath, reticulate-veined on both sides, the apex abruptly short-acuminate, the base narrowed or obtuse, the petioles 5–15 mm. long; fruiting racemes slender, solitary, 6–9 cm. long; pedicels numerous, about 1.5 mm. long; ocreolae truncate, less than 1 mm. long, subpapillose, the sepals ovate.

On rocky crest in woods, Loma del Gato, Cobre Range of Sierra Maestra, Oriente (*Léon, Clement and Roca 10167*).

Talauma (?) **orbiculata** Britton & Wilson, sp. nov.

Tree 6–8 m. tall, with glabrous branches. Leaves orbicular, 8–12 cm. in diameter, rounded or subtruncate at the apex, rounded or truncate at the base, glabrous and prominently reticulate-veined on both sides, the midrib flat above, prominent beneath, the petioles rather slender, 3–6 cm. long, flat or shallowly grooved above, glabrous; sepals broadly elliptic, 2.6 cm. long, 2–2.3 cm. broad; petals thick, oblong or elliptic, about 2 cm. long, 0.8–1 cm. wide; carpels tomentulose.

Loma de Quintin, Nagua, Oriente (*Léon 10955*).

Persea anomala Britton & Wilson, sp. nov.

A shrub or tree, sometimes 10 m. tall, with appressed-pubescent twigs. Leaves lanceolate to ovate or elliptic, 4–10 cm. long or less, 1.8–5.5 cm. broad, rounded, obtuse, or acutish at the apex, rounded or somewhat acutish at the base, glabrous and reticulate-veined on both sides, the petioles slender, 1–1.8 cm. long; branches of the inflorescence pubescent with appressed hairs; calyx pubescent, greenish, its lobes unequal, the outer broadly ovate, about 1 mm. long, 0.7 mm. broad, the inner elliptic or broadly ovate, 1.7–2 mm. long, 1.5–1.7 mm. broad; berry subglobose, 11 mm. long, black.

Sierra Maestra, Oriente (*Léon 10707*, type; *10975; 10976; 10079; 11057*).

Persea similis Britton & Wilson, sp. nov.

Twigs appressed-pubescent. Leaves elliptic, 4–7 cm. long, acute or short-acuminate at the apex, acute at the base, dark green and glabrous above, the midvein impressed, paler beneath and pubescent with short appressed hairs, the lateral veins rather indistinct on both sides; petioles 3–4 mm. long; inflorescence pubescent with appressed brownish hairs; calyx-lobes elliptic to oval, 1.8 mm. long, about 1 mm. broad, appressed-pubescent.

Sierra Maestra, Oriente (*Léon 11058*).

Nectandra reticularis Britton & Wilson, sp. nov.

A shrub with pubescent twigs. Leaves elliptic-lanceolate, 3.5–6.8 cm. long, 1–2.3 cm. broad, acute to acuminate at the apex, acute at the base, glabrous, dark green, shining and reticulate-veined above, paler and reticulate-veined beneath; petioles 7 mm. long or less; inflorescence long-peduncled, the peduncle puberulent; flowers short-pedicelled; calyx white, its lobes elliptic, 1.5 mm. long, about 1 mm. broad, puberulent; drupe ellipsoid, about 1.1 cm. long, 6 mm. in diameter.

Sierra Maestra, Oriente (*Léon 10746*, type; *10958*).

Rubus turquinensis Rydberg, sp. nov.

Stem terete, 1–2 m. high, densely fuscous, villous-tomentose and with numerous stalked glands, armed with somewhat compressed curved pubescent prickles 4–8 mm. long; leaves of the branches 3-foliolate, those of the main stem not seen; petiole and ribs of the leaflets villous-tomentose, glandular, and slightly prickly; petiolule of the terminal leaflet 7–15 mm. long, those of the lateral leaflets 1–4 mm. long; leaflets lanceolate, long-acuminate, mostly rounded at the base, finely and closely serrate, 3–10 cm. long, dark-green, sparingly pubescent and somewhat glandular-granuliferous above, paler and somewhat fuscous and densely short-villous, almost subvelutinous, beneath; racemes 3–6 cm. long, 5–10-flowered; peduncles and pedicels densely pubescent and glandular, slightly prickly; sepals lanceolate, acuminate, 5–6 mm. long, glandular and pubescent without, grayish-tomentose within; berry about 1 cm. long and 7–9 mm. thick; drupelets many, glabrous.

Type collected on the top of Pico Turquino, Oriente, Cuba, July 23, 1922, *Léon 10755* (New York Botanical Garden); also at an altitude of 1600 m. on the same mountain, *10756.*

R. turquinensis is a member of the *Adenotrichi*, differing from *R. costaricanus* and *R. adenotrichos* in the narrower lanceolate long-acuminate, instead of broadly ovate, abruptly acuminate leaflets; from *R. Vera-Crucis* in the more dense pubescence and the texture of the leaves. It is more closely related to *R. irasuensis* and *R. miser.* In habit, leaf-form, and pubescence it resembles the former, but the inflorescence is mostly simple, the sepals narrower, and the drupelets perfectly glabrous; neither have any 5-foliolate leaves been seen. From *R. miser* it differs in the shorter sepals and the thicker leaflets, with shorter petioles, more numerous and more prominent lateral veins, and much closer serrations.

Polygala scabridula Blake, sp. nov.

Virgate leafy shrub 2–3 m. high, the branches erect, hispidulous. Petioles hispidulous, 2 mm. long; leaf blades obovate, 1.3–1.8 cm. long, 9–12 mm. wide, broadly rounded at apex, rounded or cuneate-rounded at base, coriaceous, scabrid-hispidulous above with persistent ascending hairs, similarly pubescent beneath; racemes axillary, the axis few-flowered, about 1 mm. long, the peduncle obsolescent; pedicels glabrous, 1.2 mm. long; flowers immature; sepals deltoid-ovate, ciliolate, obtuse, 1.1 mm. long; wings similar, 1.4 mm. long and wide; keel ciliate, otherwise subglabrous, 2.5 mm. long; capsule subquadrate, rather broadly margined, slightly wider at the apex, ciliolate, otherwise glabrous, 6 mm. long, 8.5 mm. wide, lobed for about 1/3 its length; seed ellipsoid, sparsely pubescent, 4 mm. long; aril orange, 1.8 mm. deep, with repand lateral margin, the dorsal lobe 1 mm. long.

Sabana de Motembo, Santa Clara, August 9–10, 1920 (*Léon and Loustalot 9333*).

This species is related to *Polygala portoricensis* (Britton) Blake, of Porto Rico, which has larger emarginulate leaves, and a smaller, less deeply lobed capsule.

Polygala rhynchosperma Blake, sp. nov.

Slender erect annual, 14–25 cm. high, simple or few-branched above, evenly but not densely puberulous with short, thickish, incurved or subappressed eglandular hairs. Leaves alternate except for 1 or 2 basal whorls, rather crowded, short-petioled, the blades linear, 6–14 mm. long, 0.5–1.3 mm. wide, acute, cuspidulate, 1-nerved, sparsely puberulous like the stem, erect; peduncles 5–15 mm. long; racemes slender, cylindric, gradually narrowed to an obtuse apex, loose below, 2–9 cm. long, the axis becoming 10.5 cm. long and more, puberulous like the stem; bracts oval or obovate, caducous, 1.5 mm. long, puberulous at base, with rather short abrupt caudate purplish tips; pedicels glabrous, 1 mm. long, clavellate; sepals pinkish white with greenish center, glabrous, the upper oval-ovate, obtuse, 1.5 mm. long, the 2 lower oblong, obtuse, 1.2–1.5 mm. long, sometimes obscurely 1-denticulate on each side near apex; wings pinkish (when dried), obovate, 3 mm. long, 1.5 mm. wide, rounded or obtuse, scarcely clawed, 3-nerved; upper petals slightly shorter than keel, the free portion obliquely ovate, obtuse, 3-nerved; keel 3–3.2 mm. long, slightly surpassing the wings, the crest on each side of a deeply trifid lamella and a 2- or 3-fid or 2-parted lobe with linear segments; capsule pendulous at maturity, slightly surpassing the wings, elliptic-oblong, emarginate, 3.3 mm. long, 1.5 mm. wide; seeds subcylindric, 2.2 mm. long, densely short-pilose, distinctly rostrate at base (beak conic, 0.4 mm. long); aril fastened to upper half of beak, 0.7 mm. long, the 2 lobes rhombic, acute or obtuse, appressed; stigma with short blunt retrorse lower lobe and substipitate penicillate upper lobe.

Sabana del Cerro, near Zarzal, Oriente, July, 1922 (*Léon 10990;* type No. 1,049,981, U. S. National Herbarium).

Among North American species *Polygala rhynchosperma* is nearest *P. paniculata* L., which is densely stipitate-glandular and has shorter wings and an erostrate seed. The Venezuelan *P. Funkii* Chod., known to me only from Chodat's description and figures, is evidently closely related, having similar bracts, seed, and stigma. It is described as glabrous, with acute lance-elliptic sepals, acute wings, and a crest composed on each side of an acute triangular entire lamina and an undivided linear lobe.

Polygala ambigens Blake, sp. nov.

Stems usually solitary from a slender but evidently perennial root, simple or sparsely branched, 3.5–6 dm. high, very slender, glabrous throughout or sparsely incurved-puberulous on the younger parts; leaves alternate, linear or linear-filiform, 9–25 mm. long, 0.5–1.5 mm. wide, cuspidulate, short-petioled, 1-nerved, the margins often inflexed; peduncles 5–10 mm. long; racemes loosely many-flowered, the axis sometimes becoming 25 cm. long; bracts subulate, 1.5 mm. long, caducous; pedicels glabrous, 1.5–2 mm. long; sepals bearing 3–6 pairs of stipitate glands, sometimes also ciliolate with eglandular hairs toward apex, the upper sepal 2 mm. long, the lower sepals (connate nearly to apex) 1.5 mm. long; wings magenta-purple, broadly and obliquely cuneate-obovate, 3.8–4.5 mm. long, 2.8–3.2 mm. wide, subsessille or short-clawed, emarginate at apex, glabrous, about 5-veined, the veins loosely anastomosing, not at all prominulous; upper petals magenta-purple; keel yellow-tipped, becoming 4 mm. long; capsule 3.8 mm. long, 2.4 mm. wide, slightly shorter than the mature wings; seed densely pilose, 2.8 mm. long; aril sparsely pubescent on the sides, 0.8 mm. high.

Sabana del Cerro, near Cerro Pelado, between Zarzal and Nagua, Oriente, July, 1922 (*Léon 10860;* type No. 1,049,889, U. S. National Herbarium).

Nearly related to *Polygala cubensis* Chod., which is an annual with shorter sepals (1.1–1.3 mm. long), and somewhat smaller wings shorter than the capsule. In its slender but evidently perennial root resembling *P. Wrightii* Chod., which is densely incurved-puberulous and has the sepals ciliate with eglandular hairs. Much more material of the Cuban representatives of this group (section *Adenotricha* of subgenus *Hebeclada*) must be accumulated before the specific characters can be established satisfactorily.

Maytenus saxicola Britton & Wilson, sp. nov.

A glabrous shrub, 4 m. high, with rather stiff, somewhat flexuose twigs. Leaves elliptic to elliptic-ovate, rigid-coriaceous, 3–6 cm. long, 1.5–3.3 cm. broad, obtuse or rounded at the apex, acute at the base, dark green above, paler beneath, the midvein elevated on both sides, the lateral veins often rather indistinct, the margin minutely crenulate; petioles 5 mm. long or less; pedicels slender, up to 7 mm. long; capsule globose-obovoid, 8 mm. long, 7–8 mm. in diameter.

On rocks, Sierra Maestra, Oriente (*Léon, Clement and Roca 10221*).

Rhamnidium bicolor Britton & Wilson, sp. nov.

A shrub, with slender puberulent twigs. Leaves opposite, elliptic or ovate-elliptic, 8 cm. long or less, repand-crenate, membranous, the apex acuminate, the base rounded or subtruncate, the venation ascending, densely and finely reticulate-veined on both sides, the upper surface green and glabrate, the under side whitish puberulent, the petioles 6–10 mm. long; stipules obliquely linear-lanceolate, nearly as long as the petioles; inflorescence axillary, glabrous; peduncles nearly as long as the petioles; flowers subglomerate; pedicels very short; sepals triangular-ovate, 2.5 mm. long, acute, glandular-dotted; petals orbicular-obovate, 1.5 mm. long, about 1.5 mm. broad.

High Sierra Maestra, Oriente (*Léon 11025*). Other specimens from the Sierra Maestra (*Léon 10952*), in foliage only, have entire leaves, somewhat larger, and may represent another species.

Ouratea xolismaefolia Britton & Wilson, sp. nov.

A glabrous shrub, with slender terete twigs. Leaves oblong, elliptic, or elliptic-obovate, coriaceous, 3 cm. long or less, the midvein prominent, the lateral venation delicate and nearly obscure, the apex rounded or emarginate, the base narrowed or cuneate, the petioles 1–2 mm. long; pedicels slender, 5–6 mm. long, sepals elliptic to oval, 3 mm. long; petals obovate, 4–4.5 mm. long, 3 mm. broad, rounded or truncate at the apex; anthers 3 mm. long.

High Sierra Maestra, Oriente (*Léon 10911*).

Taonabo monticola Britton & Wilson, sp. nov.

A glabrous shrub, 1 m. or more tall, with light brown twigs. Leaves elliptic-obovate, rigid-coriaceous, 2–5 cm. long, 1.3–2.5 cm. broad, rounded at the apex, acute at the base, indistinctly veined, the midvein impressed above; petioles 4 mm. long; peduncles 2–3 cm. long; sepals 5, the outer oval to suborbicular, 5.5–6 mm. long, 5–5.5 mm. broad, glandular-ciliate, the inner 4.5–5 mm. broad, rigidly and sharply acute, without marginal cilia; fruit (immature?) ovoid, 9.5 mm. in diameter.

Sierra Maestra, Oriente (*Léon 10839*, type; *10837; 11193*).

Taonabo Leonis Britton & Wilson, sp. nov.

A glabrous shrub, with light-gray twigs. Leaves obovate, 2.5–5 cm. long, 1.4–2.7 cm. broad, rounded or truncate and often slightly emarginate at the apex, acute at the base, indistinctly veined, dark green above, paler beneath, the petioles 2–3 mm. long; peduncles 3–7 mm. long, reflexed; sepals 5, the outer oval, 4.7–5 mm. long, 4 mm. broad, rounded at the apex, glandular-ciliate, the inner elliptic, 3–3.5 mm. long, acute, without glandular cilia.

Vicinity of Pico Turquino, Oriente (*Léon 10910*).

Haemocharis angustifolia Britton & Wilson, sp. nov.

A tree 20–30 m. tall, with slender grayish brown twigs, pubescent with strigillose hairs. Leaves oblong or oblong-obovate, 2–5.5 cm. long, 0.5–1.3 cm. broad, obtuse or rounded at the apex, acute at the base, light green and glabrous above, paler beneath and pubescent; flowers about 3 cm. in diameter; sepals oval or suborbicular, 4.5–6 mm. long, 4–6 mm. broad, pubescent on the back with appressed hairs; petals obovate, 1.2–1.3 cm. long, 6–7 mm. broad, rounded at the apex, pubescent; filaments filiform, glabrous; ovary villous.

Sierra Maestra, Oriente (*Léon, 11072*).

Begonia lomensis Britton & Wilson, sp. nov.

Suffruticose, the stems 3–4.5 dm. high, rusty pilose. Leaves obliquely cordate-ovate to obliquely suborbicular, 1.5–4 cm. long, 1–2.7 cm. wide, acute, glabrous above at maturity, rusty pilose or nearly glabrous beneath, coarsely toothed, the petioles 4–20 mm. long, pilose; stipules lanceolate, acuminate, entire, 4–6 mm. long, 1.5–2 mm. broad; inflorescence long-peduncled; staminate flowers; pedicels slender, up to 7.5 mm. long, glabrous; sepals 2, orbicular, 7–8 mm. long, 8–9 mm. wide; petals 2, obovate, 4 mm. long, 3 mm. wide; stamens 20 or more; capsule long-pedicelled, the body 8–9 mm. long, 5–6 mm. wide, the wing about 9 mm. broad, obtuse or acutish.

Farallones de la Loma Regino, Oriente (*Léon 10731*).

Ginoria montana Britton & Wilson, sp. nov.

A glabrous unarmed shrub, with slender ascending branches. Leaves lanceolate, coriaceous, 2.5–4.3 cm. long, 0.7–1.7 cm. broad, obtuse at the apex, acute at the base, faintly reticulate-veined; petioles slender, 2 mm. long; cymes sessile or nearly so; flowers immature, long-pedicelled; calyx-lobes spreading, appendaged below the sinuses; stamens about 20.

Sierra Maestra, Oriente (*Léon 11009*).

Psidium (?) **cacuminis** Britton & Wilson, sp. nov.

Glabrous, with straight slender twigs. Leaves oblong, thick-coriaceous, 4–7 cm. long, reticulate-veined, sparingly punctate, bright green and shining above, pale green beneath, the apex rounded or obtuse, the base narrowed, the stout petioles about 6 mm. long; fruit oblong, solitary and nearly sessile in upper axils, nearly 2 cm. long.

Pico Turquino, Oriente (*Léon 10749*).

Calyptranthes montana Britton & Wilson, sp. nov.

A much-branched shrub, with slender glabrous branches, the twigs rusty-brown and somewhat pubescent when young. Leaves lanceolate, coriaceous, 9–30 mm. long, 6–11 mm. broad, obtusely acuminate at the apex, acute at the base, rusty brown and pubescent when young, glabrous at maturity, the lateral veins rather prominent on both sides; petioles 0.9 mm. long or less; inflorescence 1–3-flowered, the peduncles filiform, 7 mm. long or less; buds globose-ovoid, 1.5 mm. in diameter.

Sierra Maestra, Oriente (*Léon 10805*).

Eugenia cati Britton & Wilson, sp. nov.

A glabrous shrub or small tree, the twigs slender. Leaves elliptic to elliptic-obovate, chartaceous, 7 cm. long or less, rather sparingly punctate, dark green above, pale beneath, not very conspicuously veined, the apex rounded or obtuse, the base mostly narrowed, the petioles 3–7 mm. long; flowers glomerate in the axils; calyx-lobes suborbicular, about 3 mm. broad.

In woods, Loma del Gato, Cobre Range of Sierra Maestra, Oriente (*Léon, Clement and Roca 10045*, type; *10588*).

Eugenia ginoriaefolia Britton & Wilson, sp. nov.

Glabrous; twigs slender. Leaves ovate to elliptic, chartaceous, 3–7 cm. long, dark green and shining above, rather prominently veined, pale beneath, densely punctate, the apex obtuse, the base obtuse or narrowed, the petioles only 3 mm. long or less; flowers glomerate at the nodes of twigs, sessile; calyx-lobes about 2 mm. broad, densely glandular, glabrous; petals elliptic to oval, about 3 mm. long, 1.8–2.2 mm. broad, obtuse or acutish at the apex; filaments filiform, glabrous, the anthers elliptic.

Sierra Maestra, Oriente (*Léon 10812*).

Eugenia lomensis Britton & Wilson, sp. nov.

Shrub 2–3 m. high, with slender pubescent twigs. Leaves lanceolate or elliptic, coriaceous, 3.5–7 cm. long, 1.7–3 cm. broad, acuminate at the apex, acute at the base, glabrous or nearly so above, the midrib and lateral veins impressed, pubescent beneath, the midvein prominent; petioles 2.5 mm. long or less; fruit subglobose, 9 mm. in diameter, black, slender-peduncled, solitary or clustered in the axils of the leaves.

Foothills of the Sierra Maestra, Oriente (*Léon 10794*, type; *10962*).

Eugenia brevipetiolata Britton & Wilson, sp. nov.

A glabrous shrub, with rather thick brownish gray twigs. Leaves oval to suborbicular, 5–8 cm. long, 4–6.5 cm. broad, rounded at both ends, dark yellowish green above, paler beneath, the midrib impressed above, prominent beneath, the lateral veins slender, slightly elevated on both surfaces; petioles stout, 2–3 mm. long; buds subglobose, 6 mm. in diameter, solitary or few together in the axils of the leaves, glabrous.

Sierra Maestra, Oriente (*Léon 11046*).

Eugenia rigidula Britton & Wilson, sp. nov.

Shrub 1 m. tall, with slender brownish pubescent twigs. Leaves lanceolate to ovate-lanceolate, rigid-coriaceous, 1–2.8 cm. long, 4–11 mm. broad, acute at the apex, rounded at the base, sparingly pubescent on both sides when young, glabrous at maturity, the petioles 1 mm. long or less; young fruits subglobose, 4–5 mm. in diameter, pubescent with appressed whitish hairs.

Edge of woods, Sierra Maestra, Oriente (*Léon, Clement and Roca 10634*).

Anamomis reticulata Britton & Wilson, sp. nov.

Shrub or tree, the young twigs slender, brown, puberulent, the branches gray. Leaves obovate, coriaceous, 3–4.5 cm. long, 1–2.5 cm. broad, rounded at the apex, cuneate at the base, yellowish-green above, paler beneath, sparingly pubescent on both sides when young with short appressed hairs, glabrous at maturity, reticulate-veined; branches of the inflorescence appressed-pubescent; flowers undeveloped.

Sierra Maestra, Oriente (*Léon 10968*).

Graffenrieda rufescens Britton & Wilson, sp. nov.

Shrub 3 m. tall, the branches, twigs, calyx and under surface of the leaves densely scurfy with brownish scales. Leaves elliptic, 4.5–10 cm. long, 2.4–4 cm. wide, acuminate at the apex, acute at the base, 3-nerved, dark green and glabrous above, the petioles 1–2 cm. long; inflorescence much-branched; flowers short-pedicelled; calyx-tube 3–3.5 mm. long, 8-ribbed, its lobes semiorbicular, 1 mm. long or less; petals suborbicular or orbicular-obovoid, 3.5 mm. long, 3–3.5 mm. wide, yellow.

Sierra Maestra, Oriente (*Léon 11047*).

Miconia plumieriaefolia Britton & Wilson, sp. nov.

Shrub, the twigs, petioles and branches of the inflorescence clothed with a dense brownish white stellate scurf. Leaves

3-nerved, oblong or oblong-lanceolate, coriaceous, 10.5–15 cm. long, 2.5–3.8 cm. broad, green and glabrous or nearly so above, densely ferruginous-pubescent beneath with short stellate hairs, reticulate-veined, the lateral veins 2–3 mm. distant, nearly at right angles to the midrib, the petioles 1.5–2 cm. long; branches of the inflorescence loosely articulate; pedicels 2–4.5 mm. long; flowers undeveloped; calyx-lobes shortly triangular-ovate.

Sierra Maestra, Oriente (*Léon 10925*).

Rapanea microphylla Britton & Wilson, sp. nov.

A glabrous shrub, with short and slender twigs. Leaves obovate or oblong-obovate, coriaceous, 8–20 mm. long, pinnately few-veined, punctate, the apex rounded, the base connate, the petioles 2–3 mm. long; fruits nearly sessile, subglobose, shining, about 3 mm. in diameter.

Pico Turquino, Sierra Maestra, Oriente (*Léon 10714*).

Symplocos Leonis Britton & Wilson, sp. nov.

Shrub, the twigs dark brown, strigillose. Leaves elliptic, subcoriaceous, 4–8.5 cm. long, 2–4 cm. broad, rounded or obtusely acute at the apex, acute at the base, dark green, glabrous and indistinctly reticulate-veined above, the midrib impressed, paler, reticulate-veined and pubescent with appressed hairs especially on the midvein beneath, or nearly glabrous; petioles about 5 mm. long; inflorescence pubescent with ferruginous hairs; calyx-lobes elliptic, 1.4 mm. long, 0.9 mm. broad; petals 5, broadly oval, 3–3.5 mm. long, 2.5 mm. broad, glabrous; filaments distinct nearly to the base; fruit ellipsoid, 8.5 mm. long, 5.5 mm. in diameter, pubescent with scattered appressed hairs.

Sierra Maestra, Oriente (*Léon 10738*, type; *10907*).

Plumiera montana Britton & Wilson, sp. nov.

A tree up to 10 m. high or higher, glabrous throughout. Leaves oblanceolate, 15 cm. long or less, membranous when dry, the lateral venation rather widely spreading, the apex rounded, the base cuneate, the slender petioles 1–3 cm. long; flowers several or numerous; pedicels rather stout, 1.5 cm. long or less; calyx about 5 mm. long; corolla (white?) its slender tube about 2 cm. long, about one-half as long as the narrowly oblanceolate, rounded lobes; pod about 12 cm. long.

Sierra Maestra, Oriente. Type from banks of Yara River (*Léon 11060*).

Marsdenia bicolor Britton & Wilson, sp. nov.

A slender vine, with puberulent stems. Leaves oblong-elliptic to elliptic, 5–6.5 cm. long, 1.5–3.2 cm. broad, green above, whitish beneath, glabrous on both surfaces, the lateral veins indistinct; calyx-lobes ovate, 4 mm. long, about 2 mm. broad, acute or acuminate, slightly pubescent; corolla 1.5 cm. long, 1.5–1.8 cm. wide, glabrous, its lobes triangular, 6 mm. long, 5.5–6 mm. wide.

Sierra Maestra, Oriente (*Léon 10787*, type; *10788*).

Sebesten Leonis Britton & Wilson, sp. nov.

A tree up to 15 m. high, the young twigs sparingly pubescent, soon glabrous and gray. Leaves thick-coriaceous, glabrous or the short and stout petioles sparingly pubescent, shining, elliptic, oblong or obovate-elliptic, 5–9 cm. long, the venation impressed above, prominent beneath, the apex rounded, the base obtuse or rounded, the petioles only 8 mm. long or less, the upper surface dark green, the under surface light green; flowers several in terminal clusters; calyx subcylindric, nearly 2 cm. long, densely puberulent, its teeth very short and broad; corolla funnelform, its tube about 3 cm. long, enlarged upward, the widely spreading limb about 4 cm. broad, about 6-lobed; fruit ovoid, about 2 cm. long, its summit beaked.

Loma de Naranjo, Sierra Maestra, Oriente, at 600 m. elevation (*Léon 11021*).

Varronia longipedunculata Britton & Wilson, sp. nov.

A shrub with slender branches, the young twigs puberulent. Leaves elliptic or oblong, chartaceous, 7 cm. long or less, scabrate above, puberulent on the veins beneath, entire or sparingly repand, the apex obtuse or acute, the base mostly narrowed, the puberulent petioles 6–12 mm. long; peduncles solitary, slender, puberulent, longer than the leaves; flowers several in a terminal globose head about 1.5 cm. in diameter; calyx-lobes triangular, 1.5 mm. long, acute; corolla-lobes broadly obovate, 7.5 mm. long, 4.5 mm. broad.

Sierra Maestra, Oriente (*Léon 10964*).

Salvia scopulorum Britton & Wilson, sp. nov.

A shrub, about 3 m. high, the branches densely pubescent with short spreading hairs. Leaves ovate, coriaceous, crenulate, 3–5 cm. long, 1.5–3 cm. broad, acute to abruptly short-acuminate at the apex, rounded and often more or less subcordate at the base, dark green above, paler beneath, pubescent on both sides, the petioles 12 mm. long or less; calyx 10–11 mm. long, finely pubescent; corolla red, 1.8 cm. long or more, pubescent.

Farallones de Regino, Estribo Turquino, Oriente, 1600 m. alt. (*Léon 11010*).

Rondeletia naguensis Britton & Wilson, sp. nov.

A shrub about 2 m. high, the young twigs and inflorescence densely strigose. Leaves elliptic, subcoriaceous, 4–10 cm. long, sparingly strigose on the veins beneath when young, soon glabrous, the apex obtuse or acute, the base obtuse or narrowed, the venation inconspicuous, the strigose petioles 6–12 mm. long; flowers in peduncled heads, the peduncles 2–4 cm. long; bractlets obovate, about 3 mm. long; calyx-lobes oblanceolate, 3.5–4 mm. long, densely pubescent with appressed hairs; capsule subglobose, 5.5 mm. in diameter, appressed-pilose.

Banks of a stream, Loma de Quintin, Nagua, Oriente (*Léon 10971*).

Rondeletia calophylla Standley, sp. nov.

Branchlets slender, pilose-strigose; stipules deltoid-acuminate, 1.5 to 2.5 mm. long, erect, persistent; petioles stout, 2 mm. long, strigillose; leaf blades ovate, sometimes broadly so, 2 to 3.5 cm. long, 1 to 2.5 cm. wide, acute or sometimes obtuse, broadly rounded or subcordate at base, thick-coriaceous, dark green above, lustrous, scaberulous or glabrate, the venation prominulous-reticulate, much paler beneath and brownish, glabrate or scaberulous along the nerves, the costa prominent, the lateral nerves few and distant; inflorescence terminal on the main branches and on leafy lateral twigs, few-flowered, lax, the flowers pedicellate; calyx globose, densely whitish-strigillose; calyx lobes 5, oblong or linear-oblong, 2 mm. long, obtuse, glabrate, suberect; corolla densely white-strigillose outside, the tube 4 mm. long, the 5 lobes rounded, 2 mm. long; capsule subglobose, 3–4 mm. broad, glabrate; seeds broadly winged.

Type (in the U. S. National Herbarium) collected in the Sierra Maestra, Oriente, July, 1922, (*Léon 10741*).

In the key to the species of *Rondeletia* in the North American Flora, this plant runs at once to the group *Odoratae*, but it is not closely related to any of the species placed there, or to any other Cuban species previously known to the writer.

Guettarda cryptantha Standley, sp. nov.

Shrub, the branches grayish, the branchlets slender, densely pilose with subappressed fulvous hairs; stipules 8–10 mm. long, oblong-lanceolate, long-acuminate, appressed-pilose; leaves opposite, the petioles stout, 2–3 mm. long, appressed-pilose, the blades elliptic or ovate-elliptic, 2.5–6 cm. long, 1.2–3 cm. wide, rounded at base, obtuse or rounded at apex, coriaceous, dark-green above, lustrous, at first pilose with very slender whitish appressed hairs but later glabrate, the venation depressed, paler and brownish beneath, thinly scaberulous-pilosulous and with longer subappressed hairs along the veins, the costa stout and prominent, the lateral veins 5–7 pairs, subarcuate, anastamosing, remote from the revolute margin; inflorescence few-flowered, closely sessile, terminal and axillary, subtended by large, densely pilose, oval bracts; hypanthium densely sericeous-pilose with long whitish hairs, the calyx 5–7 mm. long, cleft into 3 or 4 spatulate-obovate, obtuse, densely sericeous lobes; corolla brownish-red, the tube stout, 10–12 mm. long, densely pilose with long whitish ascending hairs, the 4 lobes rounded-oval, 4 mm. long, glabrous within.

Type collected on Loma del Gato, Cobre Range of Sierra Maestra, Oriente, altitude 900–1000 meters (*Léon, Clement and Roca 10301;* herbarium of the New York Botanical Garden).

Guettarda cobrensis Standley, sp. nov.

Shrub 3 meters high, the branches dark reddish brown, the branchlets thick, densely covered with minute appressed fulvous hairs, the internodes short; stipules oblong-ovate, 4 mm. long or more, acuminate, thin, brown, pubescent like the branchlets and with few long subappressed hairs; leaves opposite, the petioles stout, 4–6 mm. long, minutely and densely appressed-pilose, the blades oval or broadly oval, 3–6 cm. long, 2–4.5 cm. wide, rounded at apex, deeply cordate at base, thick-coriaceous, yellowish-green, concolorous, often somewhat bullate, glabrous above, the venation depressed, beneath bearing a few short appressed hairs along the coarse prominent costa, but elsewhere glabrous, the lateral veins stout and prominent, 5 or 6 on each side, subarcuate, ascending at an angle of 45–60°, the intermediate veins inconspicuous, the margin subrevolute; peduncles about 1 cm. long, pubescent like the branchlets, the flowers usually 3, sessile; fruit globose, 1 cm. in diameter, minutely tomentulose.

Type collected at edge of woods, Loma del Gato, Cobre Range of Sierra Maestra, Oriente, altitude 800 meters (*Léon, Clement and Roca 10271;* herbarium of the New York Botanical Garden).

Related to *G. crassipes* Britton, in which the leaves are densely long-pilose beneath along the costa.

Stenostomum apiculatum Britton & Standley, sp. nov.

Branchlets thick, resinous, densely leafy, sericeous-strigose; stipules united, persistent, the sheath 5 mm. long, densely strigose; petioles stout, 5–12 mm. long, densely strigillose; leaf blades elliptic, 4.5–7 cm. long, 2.5–4 cm. wide, obtuse or acute at base, obtuse at apex and apiculate-acuminate, coriaceous, green above, lustrous, glabrous, the costa depressed, paler beneath and brownish, sparsely strigillose, the veins prominent, the lateral ones about 9 pairs, arcuate, distant, the margin plane or subrevolute; peduncles slender, about 3 cm. long, the 2 branches 2–2.5 cm. long, 10–12-flowered; calyx and hypanthium 1–1.5 mm. long, glabrate, the calyx with very short, obtuse teeth; corolla 7 mm. long, densely strigillose outside; filaments very short, the anthers oblong-linear, equaling the corolla tube; stigma 4-lobate.

Type (in the U. S. National Herbarium) collected in the Sierra Maestra, Oriente, July, 1922 (*Léon, 10806.*)

Psychotria Leonis Britton & Wilson, sp. nov.

Shrub, the twigs and branches of the inflorescence puberulent. Leaves elliptic to oval, 3–5 cm. long, 1.5–3 cm. broad, acute to short-acuminate at the apex, acute at the base, glabrous above, pubescent beneath when young with short appressed hairs, the primary veins indistinct above, prominent beneath; petioles 1.3–1.5 cm. long, puberulent; panicles few-flowered; calyx funnel-shaped, shallowly toothed, the teeth triangular, acute; buds narrowly ellipsoid, puberulent; mature flowers and fruits not seen.

Sierra Maestra, Oriente (*Léon 10789*).

Lobelia cacuminis Britton & Wilson, sp. nov.

Suffrutescent, the stems 3–4 m. high, nearly glabrous. Leaves chartaceous, oblanceolate, 7–13 cm. long, 2.5–4.5 cm. wide, acuminate at the apex, cuneate at the base, rather coarsely dentate, the petioles 1.5–3 cm. long; midrib flat above, prominent beneath, the lateral veins ascending; inflorescence many-flowered; pedicels slender, 10–12 mm. long, pubescent; calyx-lobes narrowly lanceolate, 3–4 mm. long; mature corolla not seen; young fruits 1 cm. in diameter.

Pico Turquino, Oriente (*Léon 10862*).

Senecio Leonis Britton & Wilson, sp. nov.

Vine, the slender stems glabrous. Leaves ovate, triangular-ovate or occasionally lanceolate, 1.5–4.5 cm. long, 0.9–2.7 cm. wide, often with one or more prominent teeth at or above the base, palmately-veined, glabrous on both sides; petioles 0.5–1.5 cm. long; heads long-peduncled, the peduncles pubescent; involucre subcylindric-campanulate, 5–6 mm. high, its bracts oblong, glabrous, their tips acute or acuminate; pappus white, 4 mm. long; achene about 1 mm. long.

Climbing on shrubs, Loma del Sabicu, Oriente (*Léon 10751*).

Chaptalia montana Britton, sp. nov.

Leaves oblanceolate-spatulate, thin, 4–7 cm. long, lyrate-pinnatifid, the terminal lobe large, elliptic-obovate, obtuse, apiculate, the lateral ones few, small, rounded, the upper surface green and glabrate, the under grayish-lanate; scape filiform, 1.5–2.5 dm. long; head erect; involucre subcampanulate, its bracts linear, acuminate, lanate below, the inner ones about 7 mm. long; achenes fusiform, 5.5–6 mm. long, the slender beak longer than the body; pappus white.

Sierra Maestra, Oriente (*Léon 10802*).

65. UNDESCRIBED SPECIES FROM TRINIDAD

Bactris savannarum Britton, sp. nov.

Trunk slender, up to 10 m. high, erect, copiously armed, like the leaf-rachis, with nearly white, deflexed spines 1–5 cm. long, which turn darker in age. Leaves about 1 m. long or longer, petioled, the numerous, unarmed segments 2–4 dm. long, about 4 cm. wide or less, light green, paler beneath than above, the base attenuate, the apex acuminate or acute, some of the upper ones of young leaves confluent; spathe narrowly oblong, 2–3 dm. long-acuminate, densely appressed-bristly, the bristles rather soft; inflorescence about as long as the spathe, its axis and slender branches densely brown-villous; flowers numerous, nearly white, about 4 mm. long; fruit orange, depressed-globose, small for the genus, about 8 mm. in diameter, vertically striate; fruiting calyx nearly flat, about 5 mm. broad, its lobes rounded, striate.

Aripo Savanna and its forest borders, Trinidad (*Britton, Broadway and Hazen 269*, type; Trinidad Herbarium *9850, Broadway*); Professor L. H. Bailey has kindly sent us two photographs of this palm taken by him in 1921.

Pilea aripoensis Britton, sp. nov.

Stems filiform, 4–7 cm. long. Leaves membranous, spatulate, entire, 1-nerved, 12 mm. long or less, the apex rounded, the base cuneate, the filiform petiole somewhat shorter than the blade, the raphides linear, undulate, transverse, prominent upon the upper surface.

Hanging from wet dark banks, Heights of Aripo, Trinidad (Trinidad Herbarium *10,008*, *Broadway*).

Inga ierensis Britton, sp. nov.

A tree up to 16 m. high, the petioles, leaf-surfaces and peduncles strigillose. Petioles slender, 2–3 cm. long; rachis-glands suborbicular, semiglobose; leaflets in 2 pairs, ovate-elliptic, chartaceous, shining, 7–10 cm. long, pinnately veined, the apex rather abruptly short-acuminate, the oblique base narrowed or obtuse, the strigulose petiolules 2–3 mm. long; peduncles about 6 cm. long or less; legume broadly linear, compressed, glabrous, shining, up to 10 cm. long, about 2 cm. wide, finely striate, abruptly short-tipped, the margins continuous or deeply constricted.

Forests, northern mountain range, Trinidad. Type from the Maracas Valley (*Britton and Hazen 1627*). In fruit April 10, 1920.

Serjania ierensis Britton, sp. nov.

A vine up to 7 m. long, the branches slender, glabrous. Leaves about 6 cm. long, biternate, the short, slender petioles 1.5 cm. long or less, sparingly pubescent; leaflets coriaceous, glabrous, 4 cm. long or less, serrate, finely reticulate-veined, shining, those of the terminal segment acute or acuminate, those of the lateral segments rounded or obtuse; peduncles about as long as the leaves, glabrous; tendrils very slender, 2–4 cm. long; panicles puberulent nearly as long as the peduncles; samaras glabrous, about 15 mm. long, the wing finely reticulate-veined, about 4 times as long as the body and only partially enclosing it.

Dry thickets, Trinidad. Type from Palo Seco (*Britton and Hazen 1172*). In fruit March 30, 1920.

Clusia intertexta Britton, sp. nov.

Forming impenetrable masses with interlocking aerial roots. Leaves orbicular-obovate, 10–14 cm. long, thick-coriaceous, rounded, the base subcuneate, the lateral veins many, about 4 mm. apart, prominent on the upper surface, the very stout petioles 1 cm. long or less; inflorescence several-flowered, its branches stout; bracts 2–3 cm. long; buds globose, glabrous; fruit (immature) oblong-ovoid, beaked, about 2.5 cm. long; stigmas 6.

Forest, Heights of Aripo, Trinidad (Trinidad Herbarium *9786*, *Broadway*), January 10–26, 1922.

Clusia aripoensis Britton, sp. nov.

A tree, with slender twigs. Leaves narrowly obovate, subcoriaceous, 7–8 cm. long, the apex obtuse, the base cuneate, the rather closely pinnate venation prominent on the under side, almost wholly obscure above, the rather slender petioles 1–2 cm. long, stigmas 5; young fruit obovoid, 2.8 cm. long, 2 cm. in diameter.

Forest, Heights of Aripo Trinidad (Trinidad Herbarium *9785*, *Broadway*), January 10–26, 1922.

Stylogyne tenuifolia Britton, sp. nov.

A tree up to about 10 m. in height. Leaves elliptic, membranous, 8–20 cm. long, glabrous, the base narrowed, the apex rather abruptly acuminate, the midvein impressed above, prominent beneath, the stout petioles 5–12 mm. long; inflorescence lateral and terminal, 5 cm. long or less, short-paniculate; bractlets oblong-lanceolate, 2–3 mm. long, deciduous; pedicels nearly filiform, 5–10 mm. long; calyx-segments broadly ovate, rounded, about 2 mm. long; corolla about twice as long as the calyx; fruit globular, white, 6–7 mm. in diameter.

Forests at higher elevations in the northern mountain range, Trinidad. Type from Mt. Tocuche (*Britton, Hazen and Mendleson 1341*); collected also by Mr. Broadway on the Heights of Aripo (Trinidad Herbarium, *9837*, *9840*).

Prestonia Fendleri N. E. Brown, sp. nov.

Stem climbing, the flowering parts with internodes 4.5–12 cm. long, 1–2 mm. thick, thinly puberulous with minute curved hairs on the youngest parts, becoming glabrous and brown with age. Leaves with petioles 6–15 mm. long and blades 5–10 cm. long and 3–7 cm. broad, elliptic, subequally and broadly rounded at both ends, with a small abrupt point 1–2 mm. long at the apex, with about 5 ascending curved primary veins on each side of the midrib, inarching at their tips and forming loops near the margin. Racemes axillary, the axis 1–2 cm. long in the example seen, bearing 15 or more flowers on the upper half, flowerless below, thinly and minutely puberulous. Bracts minute, less than 1 mm. long. Pedicels 12–15 mm. long, slender, puberulous. Sepals 5 mm. long and 1.5–2 mm. broad, lanceolate, acute, thinly puberulous. Corolla pubescent at the top of the tube inside, otherwise glabrous; tube 15–17 mm. long and about 4 mm. in diameter, cylindric, with the mouth, where the lobes pass from it, raised into an erect ring 1 mm. high; inside this ring arise 5 linear erect exserted processes (coronal-lobes) 4 mm. long; lobes about 12 mm. long and 7 mm. broad, somewhat rhomboid, or obliquely subtruncate. Stamens inserted near the top of the tube, glabrous; filaments 2 mm. long; anthers sagittate, 4.5 mm. long, exserted. Ovary surrounded by an obtusely 5-lobed fleshy disk.

Trinidad, without precise locality, *Fendler 628*.

Cordia ierensis Britton, sp. nov.

A tree up to 10 m. high, with slender, finely appressed-pubescent twigs. Leaf-blades elliptic to ovate, thin, 2 dm. long or less, scabrate-puberulent, the apex abruptly acuminate, the base obliquely obtuse or narrowed, the petioles 2 cm. long or less; panicle about 8 cm. broad, broader than long, many-flowered, its branches slender, densely appressed-pubescent; flowers sessile, the buds obovoid, rounded, densely appressed-pubescent, about 2 mm. long.

Forests, Trinidad. Type from Morne Bleu (*Britton, Freeman and Bailey, 2277*). In bud March 13, 1921. This is, as determined by Mr. N. E. Brown at Kew, the *Cordia panicularis* of Grisebach, not of Rudge.

Aegiphila trinitensis Britton, sp. nov.

A shrub, with slender, glabrous branches, the bark nearly white, the young shoots brown, short, minutely puberulent. Leaves short-petioled, the blades ovate, thin, small for the genus, 4 cm. long or less, the apex acute or acuminate, the base narrowed; panicles small, short-peduncled, strigose, several-many-flowered, 2–3 cm. broad; calyx obconic, truncate, puberulent; corolla white, about 8 mm. long.

Hillsides and thickets in moist districts, Trinidad. Type from St. Ann's (*Mrs. W. E. Broadway*). In flower May 10, 1919. This is the species recorded by Grisebach from Trinidad, as *Aegiphila laevis*.

Anguria elliptica Britton, sp. nov.

A slender, glabrous, high-climbing vine, with very slender tendrils 15 cm. long or less. Petioles about 2 cm. long; leaf-blades simple, oblong-elliptic, thin, entire, about 8 cm. long, pinnately veined, the apex abruptly acute, the base obtuse; peduncles slender, longer than the leaves; staminate flowers scarlet, spicate; spikes about 3 cm. long; calyx-lobes subulate, 1 mm. long; corolla-lobes spatulate-obovate or obovate, 4 mm. long, 2–2.6 mm. broad, rounded or subtruncate and mucronate at the apex, the margin minutely ciliate; anthers 4.5 mm. long, straight.

Forests in wet or moist districts, Trinidad; type from Arima (*Britton 2084*). In flower March 4, 1921.

66. UNDESCRIBED SPECIES FROM PORTO RICO

Scleria doradoensis Britton, sp. nov.

Perennial? Culms slender, rather stiff, glabrous, erect, tufted, 3–4 dm. high. Leaves glabrous, scabrate, shorter than the culm, about 2 mm. wide, the apex attenuate; inflorescence terminal, glomerate-spicate, 5–7 cm. long; glomerules 6–8, few-flowered, not nodding; bracts about 3 mm. long, brown-ciliate; achene white, subglobose-obovoid, very obtusely trigonous, verrucose-tuberculate, 1.5 mm. long, 12-porose underneath just above the trigonous base; hypogynium none.

White sand near Dorado (*Britton, Britton and Brown 7064*).

Scleria Stevensiana Britton, sp. nov.

Perennial? rootstocks short or none; culms very slender, tufted, slightly scabrous above, weak, 4–5 dm. long. Leaves soft, scabrous-margined, 4 mm. wide or less, panicles 2 or 3, axillary, the lower stalked, the upper one nearly sessile, about 3 cm. long; bracts narrowly linear-subulate, 2.5 cm. long or less; spikelets several or numerous; achene depressed-globose, about 1.5 mm. in diameter, apiculate, glabrous, shining, faintly reticulated, nearly white, with 3 vertical brown bands; hypogynium lobes lanceolate, acuminate, glabrous.

Lares (*Stevens and Hess 4944*).

Lagenocarpus portoricensis Britton, sp. nov.

Culm stout, erect, trigonous, glabrous, about 8 dm. high. Leaves 8–12 mm. wide, nearly as long as the culm, smooth, long-attenuate, with numerous transverse veinlets; panicle narrow, puberulent, about 3 dm. long and 5 cm. thick, the lower half of staminate spikelets on nearly erect branches, the upper half of pistillate; bractlets aristate; staminate spikelets about 4 mm. long, short-stalked; scales subtending the achene obovate, subtruncate, ciliolate, mucronate; achene, with its beak, ovoid, 3 mm. long, brown with three darker blotches, the beak about as long as the body.

Wet sandy situations between Manati and Vega Baja (*Underwood and Griggs 946*, type); collected also by Sintenis near Dorado. Recorded by C. B. Clarke and by Urban as *L. tremulus* Nees.

Rynchospora Blauneri Britton, sp. nov.

Perennal by short rootstocks; culms filiform, weak, clustered, glabrous, 3–5 dm. long; leaves filiform, glabrous, shorter than the culms; spikelets narrowly oblong, 3 mm. long, few together in 2 or 3 distant compact clusters subtended by a filiform bract 3–5 cm. long; scales ovate-oblong, acute, light brown; bristles none; achene obovate, light brown with darker brown margins, smooth, about 1 mm. long; tubercle conic, acute, about one-third as long as the achene.

Sierra de Luqiullo (*Blauner 247*, in herbarium of Columbia University, collected in 1852–53). Referred by Clarke to *R. divergens.*

Rynchospora luquillensis Britton, sp. nov.

Perennial by rootstocks; culms very slender, smooth, erect, about 2 dm. high. Leaves narrowly linear, about 1 mm. wide, flat, smooth, shorter than the culm; inflorescence a small terminal cluster of few spikelets; spikelets narrowly oblong, about 4 mm. long; scales oblong, brownish, acute; bristles about 6, retrorsely barbed, a little longer than the achene; style elongated; achene narrowly obovate, smooth, brown, about 2 mm. long; tubercle subulate, about as long as the achene.

Sierra de Luquillo (*Brother Hioram 364.*)

67. AN UNDESCRIBED SIPHOCAMPYLUS FROM HAYTI

Siphocampylus pinnatisectus Gleason, sp. nov.

Stem herbaceous, erect, slender, glabrous. Leaves alternate, broadly oblong in general outline, 5–7 cm. long, 3–3.5 cm. wide, narrowed at base into a petiole, glabrous, deeply pinnatisect into a terminal and 5–7 pairs of lateral linear lobes, each lobe and the rhachis about 2 mm. wide, with 2–4 sharp salient teeth or the smaller entire, sharply acute or submucronate, with a single midvein and faint lateral veinlets; flowers in the upper axils, few in number, appearing subcorymbose by the shortened internodes, on minutely puberulent pedicels 1 cm. long; hypanthium obconic, acute at base, 3 mm. high; calyx-lobes narrowly linear-triangular, acuminate, erect, separated by narrow acute sinuses; corolla red, about 25 mm. long, narrowly tubular, somewhat curved ventrally, constricted at base, gradually enlarged upward, 3 mm. in diameter at the throat, its lobes all depressed, 3–4 mm. long.

Type, *Nash and Taylor 1701*, collected on an open sunny hillside, between La Brande and Mt. Balance, Hayti, at altitude of 3150 ft., August 15, 1905.

Siphocampylus pinnatisectus differs from all other West Indian members of the genus in its deeply pinnatisect leaves.

INDEX TO AMERICAN BOTANICAL LITERATURE
1920–1922

The aim of this Index is to include all current botanical literature written by Americans, published in America, or based upon American material; the word America being used in the broadest sense.

Reviews, and papers that relate exclusively to foresty, agriculture, horticulture, manufactured products of vegetable origin, or laboratory methods are not included, and no attempt is made to index the literature of bacteriology. An occasional exception is made in favor of some paper appearing in an American periodical which is devoted wholly to botany. Reprints are not mentioned unless they differ from the original in some important particular. If users of the Index will call the attention of the editor to errors or omissions, their kindness will be appreciated.

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Adams, J. F. Observations on frost protection and drouth spot of apple. Phytopathology **12:** 184–187. *f. 1.* 29 Je 1922.

Allen, W. E. Observations on surface distribution of marine diatoms between San Diego and Seattle. Ecology **3:** 140–145. *f. 1.* 26 Ap 1922.

Ames, O. Descriptions of new orchids from tropical America with nomenclatorial changes. Proc. Biol. Soc. Washington **35:** 81–88. 26 My 1922.

Includes 8 new species and 20 new combinations.

Anderson, F. The development of the flower and embryogeny of *Martynia louisiana.* Bull. Torrey Club **49:** 141–157 *pl. 7, 8.* 15 Je 1922.

Andrews, F. M. *Saprolegnia.* Proc. Indiana Acad. Sci. **1921:** 75–77. *f. 1, 2.* 1922.

Andrews, F. M. *Trillium nivale.* Proc. Indiana Acad. Sci. **1921:** 81–86. *pl. 1* + *f. 1.* 1922.

Andrews, F. M. *Vaucheria.* Proc. Indiana Acad. Sci. **1921:** 79–80. *f. 1.* 1922.

Arthur, J. C. Changes in phanerogamic names. Torreya **22:** 30. Mr–Ap 1922.

Barrus, M. F., & Chupp, C. C. Yellow dwarf of potatoes. Phytopathology **12:** 123–132. *pl. 7, 8* + *f. 1.* 6 Je 1922.

Benedict, R. C. The Boston fern show. Am. Fern Jour. **11:** 97–105. 31 Mr 1922.

Benedict, R. C. Evolution as illustrated by ferns. Brooklyn Bot. Gard. Leaflets **10:** 1–8. *pl. 1, 2.* 3 My 1922.

Benedict, R. C. Some plants of Chimmons Island [Long Island Sound]. Torreya **22:** 49, 50. Je 1922.

Bergman, H. F. Observations on the effect of water-raking on the keeping quality of cranberries. Am. Jour. Bot. **9:** 245–252. 21 Je 1922.

Berry, E. W. A new genus of fossil fruit. Am. Jour. Sci. V. **3:** 251–253. *f. 1. 2.* O 1922.
Calatoloides

Berry, E. W. The flora of the Cheyenne sandstone of Kansas. U. S. Geol. Survey **129:** 199–231. *pl. 46–61* 11 Ap 1922.
Includes new species in *Carpolithus* (1), *Sapindopsis* (1).

Blake, S. F. The identity of the genus *Adventina* Raf. Rhodora **24:** 34–36. 23 My 1922.
Includes *Galinsoga ciliata* (Raf.) Blake, comb. nov.

Blake, S. F. Two new species of *Acanthospermum* from the Galapagos Islands. Jour. Washington Acad. Sci. **12:** 200–205. *f. 1.*
Spp. nov. *A. brachyceratum*, *A. leptolobum.*

Blake, S. F. Two new western weeds. Science **55:** 455, 456. 28 Ap 1922.
Bassia hyssopifolia and *Centaurea picris.*

Blakeslee, A. F., Belling, J., Farnham, M. E., & Bergner, A. D. A haploid mutant in the jimson weed, *Datura Stramonium.* Science **55:** 646, 647. 16 Je 1922.

Braun, H. Effect of delayed planting on germination of seed wheat treated with formalin. Phytopathology **12:** 173–180 *pl. 13* + *f. 1–3.* 29 Je 1922.

Britton, N. L. Botanical investigations in Porto Rico. Jour. New York Bot. Gard. **23**: 49–59. Ap 1922.

Brown, J. G., & Gibson, F. Some observations on alfalfa girdle. Phytopathology **12**: 188–190. *pl. 15.* 29 Je 1922.

Browne, I. M. P. Anatomy of *Equisetum giganteum.* Bot. Gaz. **73**: 447–468. *f. 1–7.* Je 1922.

Bryan, O. C. Effect of different reactions on the growth and nodule formation of soybeans. Soil Sci. **13**: 271–302. *pl. 1–15.* Ap 1922.

Bucholz, J. T. Developmental selection in vascular plants. Bot. Gaz. **73**: 249–286. *f. 1–28.* Ap 1922.

Burgess, P. S. Studies on a drained marsh soil unproductive for peas. Univ. California Publ. Agr. Sci. **4**: 339–396. *f. 1–21.* 30 Je 1922.

Burt, E. A. Some North American Tremellaceae., Dacryomycetaceae and Auriculariaceae. Ann. Missouri Bot. Gard. **8**: 361–396. *pl. 3 + f. 1–6* N 1921.

Campbell, E. G. Some aspects of Stone Mountain [Georgia] and its vegetation. Proc. Indiana Acad. Sci. **1921**: 91–100. *f. 1–11.* 1922.

Clarkson, E. H. Experiments in naturalizing ferns. Am. Fern Jour. **12**: 19–22. 15 Je 1922.

Cook. M. T. The dissemination of peach yellows and the little peach. Phytopathology **12**: 140–142. 6 Je 1922.

Darlington, H. T. Dr. W. J. Beal's seed-viability experiment. Am. Jour. Bot. **9**: 266–269. 21 Je 1922.

Deam, C. C. Plants new to Indiana. Proc. Indiana Acad. Sci. **1921**: 101–103. 1922.

Dearness, J. & House, H.D. New or noteworthy species of Fungi II. N. Y. State Mus. Bull. **1919**: 32–43. My–Je 1920.

Includes 14 spp. nov.

DeSmidt, W. G. Studies of the distribution and volume of the wood rays in slippery elm (*Ulmus fulva*). Jour. Forestry **20**: 353–362. Ap 1922.

Doolittle, S. P. Comparative susceptibility of European and American varieties of cucumbers to bacterial wilt. Phytopathology **12:** 143–149. 6 Je 1922.

Douglas, B. The new *Alternaria* spot of tomatoes in California. Phytopathology **12:** 146–148. *f. 1.* 6 Je 1922.

Duggar, B. M., & Karrer, J. L. The sizes of the infective particles in the mosaic disease of tobacco. Ann. Missouri Bot. Gard. **8:** 343–356. N 1921.

DuMond, F. L. Branch orders and tolerance. Jour. For. **20:** 448–462. My 1922.

Durland, W. D. The forests of the Dominican Republic. Geographical Rev. **12:** 206–222. *f. 1–8.* Ap 1922.

Evans, A. W. Notes on New England Hepaticae—XVI. Rhodora **23:** 281–284. 22 Ap 1922.

Evans, A. W. Notes on North American Hepaticae—IX. Bryologist **25:** 25–33. *pl. 1.* Mr 1922.
Includes *Diplophyllum Andrewsii* sp. nov.

Evans, C. R. Effect of temperature on germination of *Amaranthus reflexus.* Bot. Gaz. **73:** 213–225. *f. 1–4.* Mr 1922.

Eyer, J. R. Notes on the etiology and specificity of the potato tip burn produced by *Empoasca mali* Le Baron. Phytopathology **12:** 181–184. *pl. 14 + f. 1.* 29 Je 1922.

Fairman, C. E. New or rare fungi from various localities. Proc. Rochester Acad. Sci. **6:** 117–139. *pl. 21, 22.* Ap 1922.
Includes 2 gen. nov. 36 spp. nov. and 3 var. nov.

Farwell, O. A. Botanical source of the cola nut of commerce. Am. Jour. Pharm. **94:** 428. Je 1922.

Fassett, N. C. *Lophotocarpus* on the northeastern river estuaries. Rhodora **24:** 71–73. *pl. 137.* 20 Je 1922.
L. calycinus var. *spongiosus* n. comb.

Ferguson, W. C. Some interesting plants from Long Island, N. Y. Torreya **22:** 43–49. Je 1922.

Fernald, M. L. *Brassica arvensis,* var. *Schkuhriana* (Reichenb.) n. comb. Rhodora **24:** 36. 23 My 1922.

Vol. 50 No. 2

BULLETIN

OF THE

TORREY BOTANICAL CLUB

FEBRUARY, 1923

Notes on Rosaceae—XIV

PER AXEL RYDBERG

ROSES OF THE PRAIRIES AND PLAINS

The area here treated comprises the states between the Mississippi River and the Rockies and north of Oklahoma, with the exception of Missouri, in which so many southern plants are found and in which the Ozark Mountains have a different flora from the plains. As a key to the groups has already been published in a preceding paper,* I shall here omit the same, and I shall omit also the general discussion of any species already treated there, only citing specimens collected in the region now under consideration.

I. SYNSTYLAE

Leaflets glabrous or slightly pubescent on the veins beneath, dark green and shiny above.	1. *R. setigera.*
Leaflets velutinous-pubescent beneath, rather dull above.	2. *R. rubifolia.*

1. ROSA SETIGERA Michx.

KANSAS: Cherokee County, 1896, *Hitchcock 676.*

2. ROSA RUBIFOLIA R. Br.

KANSAS: Manhattan, 1892, *Clothier.*

II. CANINAE

3. ROSA RUBIGINOSA L.

KANSAS: Riley County, 1896, *J. B. Norton 677*; 1897, *Clothier 1107.*

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* See Bull. Torrey Club **45**: 45–66. 1920.

[The BULLETIN for January (**50**: 1–60. *pl. 1*) was issued February 7, 1923.]

III. CAROLINAE

- Leaflets not subcoriaceous.
  - Infrastipular prickles decidedly curved, short, stout. 4. *R. palustris.*
  - Infrastipular prickles straight (rarely slightly curved), slender.
    - Leaflets decidedly pubescent beneath. 5. *R. Lyoni.*
    - Leaflets glabrous or pubescent only on the veins beneath.
      - Leaflets not glandular-dentate, the teeth usually simple. 6. *R. carolina.*
      - Leaflets glandular-dentate, often with double teeth. 7. *R. serrulata.*
- Leaflets subcoriaceous, densely pubescent beneath. 8. *R. rudiuscula.*

4. Rosa palustris Marsh.

This has been reported only in the Mississippi and Minnesota River valleys, where the more pubescent western form has been found.

5. Rosa Lyoni Pursh

Kansas: Cherokee County, *Hitchcock 978.*
Iowa: Iowa City, 1916, *Wylie.*
Also reported from Minnesota.

6. Rosa carolina L.

This has been reported from Minnesota and Kansas, but no specimens have been seen. It is found also in Wisconsin and Missouri.

7. Rosa serrulata Raf.

This has been reported from Iowa, but no specimens are now at hand.

8. Rosa rudiuscula Greene

This belongs to the *Carolina* and not to the *Cinnamomea* group, having the hypanthium bristly and with the achenes inserted in the bottom only. The infrastipular prickles are small and scarcely stronger than the bristles. It also has spreading and deciduous sepals; and the leaflets are thicker and firmer than in *R. carolina* and *R. Lyoni.* The flowers are usually corymbose and the plant has the general aspect of *R. suffulta.* Dr. Greene in the original publications cited several specimens that do not belong to the species.

MISSOURI: Vale, 1906, *Bush 3916;* Little Blue, *Bush 208* (TYPE); Dodson, Jackson County, *Bush 160;* railroad north of Morley, 1893, *Eggert*; Grain Valley, *6998.*

IOWA: Amaxa, 1909, *M. P. Somes 3825.*

INDIANA: White County, southeast of Wolcott, *Deam 32712;* Laporte County, *32395.*

IV. CINNAMOMIAE

Infrastipular prickles wanting; branches unarmed or bristly, not prickly.

Inflorescence corymbose, terminating the stem (or rarely the branches); plant mostly suffruticose; stem very bristly, usually dying back to the ground (except in *R. polyanthema* and *R. Bushii*); leaflets 9–11.

Leaves glabrous or nearly so.

Leaflets obovate, pale and glaucous on both sides. 9. *R. subglauca.*

Leaflets elliptic or oval, dark-green above.

Leaflets mostly 2–5 cm. long, not glaucous beneath, acute at the apex; plant 3 dm. high or more; flowers several. 10. *R. arkansana.*

Leaflets rarely more than 2 cm. long, mostly rounded at the apex, somewhat glaucous beneath; plant 1–2 dm. high; flowers 1–3. 11. *R. Lunellii.*

Leaflets densely pubescent, especially beneath.

Plant 3–6 dm. high, usually dying back to the ground.

Sepal erect in fruit; plant not glaucous.

Upper stipules and bracts not densely glandular; leaflets 1.5–4 cm. long; plant 3–5 dm. high. 12. *R. suffulta.*

Upper stipules and bracts densely glandular; leaflets seldom more than 1.5 cm. long; plant 1–3 dm. high. 13. *R. alcea.*

Sepals reflexed in fruit; plant glaucous. 14. *R. conjuncta.*

Plant shrubby, not dying back; branches from the upper axils soon overtopping the inflorescence. 15. *R. polyanthema.*

Inflorescence of few, either solitary or corymbose, flowers ending lateral branches; plant shrubby leaflets; 5–7 (or rarely 9 on the shoots).

Stem densely bristly even in age; stipules, petioles, and rachis often glandular-granuliferous; flowers solitary.
Hypanthium decidedly pear-shaped or elliptic, acute at the base, with a distinct neck at the top.
Leaflets conspicuously glandular-granuliferous, but scarcely at all hairy beneath, rounded-oval, often double-toothed. 16. *R. Engelmanni.*
Leaflets densely pubescent only rarely slightly glandular beneath, mostly elliptic, simple-toothed. 17. *R. acicularis.*
Hypanthium subglobose, almost without a neck; leaflets glandular-granuliferous as well as pubescent beneath. 18. *R. Bourgeauiana.*
Stem unarmed or when young slightly covered with more or less deciduous prickles; flowers solitary or few.
Leaflets decidedly and finely pubescent beneath. 19. *R. blanda.*
Leaflets glabrous on both sides, glossy. 20. *R. subblanda.*
Infrastipular prickles present.
Hypanthium globose; neck usually obsolete.
Stipules, petiole, and rachis copiously glandular; leaflets often double-toothed with gland-tipped teeth. 21. *R. Fendleri.*
Stipules, petiole, and rachis not conspicuously glandular, the first ones sometimes slightly gland-toothed.
Leaflets glabrous or nearly so. 22. *R. Woodsii.*
Leaflets finely puberulent beneath.
Young shoots armed with stout flat prickles; fruit about 15 mm. broad. 23. *R. terrens.*
Young shoots merely bristly; fruit rarely more than 10 mm. broad. 24. *R. Macounii.*
Hypanthium elongate, pyriform or elliptic, with a distinct neck. 25. *R. pyrifera.*

9. ROSA SUBGLAUCA Rydberg

This is related to *R. arkansana* Porter and *R. suffulta* Greene; from the former it differs in the decidedly obovate leaflets, rounded at the apex and more coarsely toothed; from the latter in the glabrous leaves; and from both in the glaucous foliage.

SASKATCHEWAN: Six miles east of Battle River, August 15, 1906, *Macoun & Herriot 70942, 70943*; Breakmore, July 18, 1906, *70941*; Brandon, *12589*.

A specimen from Decatur County, Iowa, collected by T. J. and M. F. L. Fitzpatrick may also belong here.

10. ROSA ARKANSANA Porter

This species was described from the Arkansas Cañon near Cañon City. The type is a glabrous plant and so described. The more common *R. suffulta* of the plains is densely pubescent. This was mistaken for *R. arkansana* by Watson, who has been followed by most American botanists. *R. arkansana* is found in the prairie region as well, but is much more local. It seems to be confined to the river valleys, while *R. suffulta* prefers the prairies and plains. *R. Rydbergii* Greene is nothing but *R. arkansana.* The peculiar hue of the upper surface of the leaves, so much emphasized by Dr. Greene, is due to some disease, probably bacterial. Some of the leaves or some part of them have retained their natural color on the upper surface. Best regarded it as a variety of *R. blanda.*

MINNESOTA: Winona, 1882, *Hasse Herbarium.*
NORTH DAKOTA: Fargo, *Bolley 129, 130.*
KANSAS: Comance County, 1897, *Carleton 254.*

11. ROSA LUNELLII Greene

This is closely related to *R. arkansana* and perhaps only a depauperate form of the same. It is, however, a much smaller plant and more glaucous, and the leaflets are more rounded at the apex.

MANITOBA: Brandon, 1887, *Fowler;* 1898, *E. S. Thompson.*
NORTH DAKOTA: Leeds, 1907 and 1908, *Lunell.*
SOUTH DAKOTA: Hermosa, 1892, *Rydberg 678a.*
NEBRASKA: Long Pine, 1893, *W. R. Dudley.*

12. ROSA SUFFULTA Greene

The first record of this species is in Hooker's Flora Boreali-Americana, where Borrer referred it to a variety of *R. stricta.* Crépin made it a variety of *R. blanda* and Watson confused it with *R. arkansana.* Dr. Greene was the first to see that it was not *R. arkansana* and proposed the name *R. pratincola*, overlooking the fact that this name had been used before. Discovering this fact twelve years later, he substituted the name *R. heliophila.* C. K. Schneider discovered the same fact a year later, but not knowing of Greene's last name, proposed *R.*

arkansanoides. All these names are superfluous, however, for the plant is the same as *R. suffulta* Greene. Besides these names several varietal names have been proposed. *R. dulcissima* Lunell is apparently based on a more luxuriant and less bristly form of this species.

13. ROSA ALCEA Greene

This species stands somewhat in the same relationship to *R. suffulta* as *R. Lunellii* does to *R. arkansana*. The plant is described as having prickly hypanthium, but this is not always the case. The upper part of the plant, especially the upper stipules and the bracts, are densely glandular, the glands often extend to the pedicels and hypanthium, the stalks of the glands sometimes become indurate and hence the hypanthium is prickly in fruit. This is sometimes also the case in *R. suffulta*, which form was described as *R. pratincola setulosa* by Cockerell.

SASKATCHEWAN: Milk River Ridge, 1895, *Macoun 10541;* Moose Jaw, *Spreadboro 10625;* also *Macoun 10539;* Regina 1903, *Fowler;* Indian Head, *1;* Prince Albert, *Macoun 12767* (?).

SOUTH DAKOTA: Deadwood, *Carr 150*.

14. ROSA CONJUNCTA Rydberg

This is related to *R. suffulta* and *R. subglabra* on the one hand, and to *R. virginiana* on the other. It differs from the last in the lack of glandular hairs on the hypanthium; in the pale green leaves with sharper toothing; in the absence of infrastipular spines; and in the insertion of the achenes, which is on the inside walls as well as in the bottom of the hypanthium. From *R. subglauca* it differs in the leaves pubescent beneath and in the reflexed sepals. It resembles *R. suffulta* in habit and pubescence, but the leaflets are more acute at the apex and cuneate at the base and glaucous, and the sepals are reflexed or spreading after anthesis. As the plant has been confused with *R. suffulta* and *R. arkansana*, this latter character caused the error in Britton's Manual, in which *R. arkansana* (which then included *R. suffulta*) was described as having spreading sepals. I am responsible for the error. *R. conjuncta* might be a hybrid of *R. suffulta* and *R. Lyoni* or some other species of the *Carolina* group, but none of the species of that group or of the *Cinnamomea* group (except the high northern *R. subglauca*) has the glaucous foliage of *R. conjuncta*. Hence it must be regarded as a distinct species.

15. ROSA POLYANTHEMA Lunell

This species resembles *R. suffulta* in the leaf-form and inflorescence, but the plant is shrubby, the upper branches soon overtopping the inflorescence. It is known only from the type locality and vicinity.

16. ROSA ENGELMANNI S. Wats.

In describing this species Dr. Watson included some eastern specimens which belong to *R. acicularis*. This has caused much confusion. Some botanists have regarded *R. Engelmanni* as a variety of *R. acicularis*, some as a mere synonym. *R. Engelmanni* is a purely Rocky Mountain species. The most eastern station from which the writer has seen the same is in the Black Hills of South Dakota. The specimens referred to it from Minnesota, Michigan and northern New York belong to *R. acicularis*. In *R. Engelmanni* the leaflets are much more rounded, without pubescence, but distinctly glandular-granuliferous beneath, usually double-toothed and with gland-tipped teeth. In *R. acicularis* on the contrary the leaflets are inclined to be elliptic, conspicuously pubescent but scarcely glandular beneath and with simple teeth.

Most of the specimens seen of *R. Engelmanni* are from Colorado and a few are from southern Wyoming. The only specimens from the region here treated are the following, but even these are not from the prairies and plains but from the mountains or wooded hills.

SOUTH DAKOTA: Spearfish Cañon, Black Hills, *Murdock 4136*; Rochford, *Rydberg 676* (in part); Custer, *Rydberg 676* (in part).

17. ROSA ACICULARIS Lindl.

Within the region the species is found only in the northern wooded part. Among other specimens may be mentioned:

MINNESOTA: Sandy Lake, *Sandberg 793*.

18. ROSA BOURGEAUIANA Crépin

Within the region it is found only in the northeastern wooded region.

MINNESOTA: Duluth, *Rydberg 8004*; St. Louis River, Carlton County, *Sandberg 130;* Two Harbors, *E. P. Sheldon.*

19. ROSA BLANDA Ait.

This species is confined within the region to the hardwood groves in the northern part. I can see no difference between the specimens from North Dakota, on which *R. gratiosa* Lunell was based, and those from the Eastern States.

MINNESOTA: Lake Minnetonka, *Sandberg, 798;* Thompson, Carlton County, *Sandberg 397;* Minneapolis, 1895, *E. P. Sheldon;* Lake Itasca, *G. B. Aiton.*

NORTH DAKOTA: near St. John, Rolette County, 1912, *Lunell* (*R. gratiosa*); Pleasant Lake, Benson County, 1912, *Lunell;* Turtle Mountains, 1912, *Lunell*; Bottineau, 1890, *Waldron.*

MANITOBA: Oak River, *Macoun & Herriot 70937;* six miles east of Forest, *Macoun & Herriot 70940.*

20. ROSA SUBBLANDA Rydberg

It is questionable if this species should be included among the prairie roses, as the following specimens are referred to it with considerable doubt.

IOWA: Grinell, 1877, *M. E. Jones.*

21. ROSA FENDLERI Crépin

This species is related to *R. Woodsii* and often confused with it. It is distinguished by the glandular stipules, petioles, and leaf-rachis. Watson distinguished it from *R. Woodsii* by the entire instead of lobed sepals. In both species they are either entire or lobed. *R. neomexiana*, *R. arizonica*, *R. puberulenta* and *R. granulifera* have been confused with it, but these all have curved prickles, while in *R. Fendleri* they are longer and more slender, straight or nearly so. *R. Fendleri* is a common species in the Rockies, ranging from Montana to northern Mexico. It extends eastward also into the plains and prairies and was redescribed from North Dakota by Lunell as *R. poetica.*

MINNESOTA: Montevideo, *Moyer 581.*

NORTH DAKOTA: Bismark, 1912, *Lunell.*

SOUTH DAKOTA: Hermosa, *Rydberg 677.*

NEBRASKA: McCalligan Cañon, Deuel County, *Rydberg 100.*

22. ROSA WOODSII Lindl.

This was published in 1820 in Lindley's Monograph. Five years later Lindley published an illustration in the Botanical Register of what he supposed to be the same, but evidently he was mistaken. In the Botanical Register (*pl. 976*) Lindley gave the following remarks:

> It was subsequently named and published by the writer of these remarks . . . but the specimens which were examined for the purpose, were so imperfect that, upon a comparison of the characters ascribed to the species with fresh specimens, they were ascertained to be materially erroneous; the stipulae, which were stated to possess the remarkable peculiarity of being convolute like those of *R. carolina*, proving to be, in fact, like those of *R. lucida*.
>
> But in M. de Candolle's Prodromus a new character is proposed for this plant. M. Seringe, by whom the article Rosa was prepared, had an opportunity of examining specimens in De Candolle's Herbarium. And yet our original error is still retained by Mr. Seringe, who has added to it more than one of his own. He defines the leaflets to be shining, while in fact they are the reverse; the sepals to be naked, which are covered with glands; and the lower pair of leaflets to be placed at a distance from the others, and fringed with glands, a peculiarity which we believe does not exist.
>
> We cannot dismiss this subject without expressing our regret that the general brilliancy of M. de Candolle's Prodromus should be tarnished by an article so inaccurately compiled as the genus Rosa is, in the 2d volume of that work.

These cutting remarks of Lindley's were wholly unwarranted, for Seringe did not assign any new characters that were not found in Lindley's original publication, and it was the latter himself that assigned new characters. Let us recite a few lines from Lindley's own description in his Monograph, page 22.

> *Leaves* without pubescence; stipules very narrow and acute, convolute and fringed with glands . . . *Leaflets* 7–9, shaped like those of *R. rubella*, shining, flat, simple, acute, paler beneath . . . *Fruit* naked, ovate, with short, connivent, entire *sepals* which are free from glands as is the peduncle.

From this it is evident that *Rosa Woodsii* of the Botanical Register is not the same as the original one described in Lindley's Monograph. This carelessness on Lindley's part has caused a great deal of confusion, and it is hard to know what the original *R. Woodsii* was. Some have suggested *R. humilis*, but as the pedicels, hypanthium and sepals were without glands and the latter connivent, this suggestion is far from the truth.

Others have suggested *R. blanda* Ait., but the true *R. blanda* is a boreal plant and not found on the Missouri, and the leaves are dull and pubescent beneath. The *R. Woodsii* of the Botanical Register might sooner be a form of that species. The only species that agrees with the description of the original *R. Woodsii* is the one that Torrey called *R. foliosa leicocarpa* and in my flora of Colorado I called *R. Macounii*, the same as Greene has described as *R. Sandbergii* and Lunell as *R. deserta.* I also think *R. fimbriatula* Greene belongs here. It is a shrub belonging to the Rocky Mountain region but extends eastward to the Missouri River. Watson referred it partly to *R. Woodsii*, partly to *R. Fendleri*. Watson assigned also new characters to *R. Woodsii*, viz. lobed sepals. Notice that Lindley originally described them as "entire." The lobing or not-lobing of the sepals is a character of no value in the *Cinnamomea* group. In other groups as for instance, the *Carolina* and *Canina* groups, it is a fairly reliable character. *Rosa Maximiiliani* Nees belongs to this species.

North Dakota: Pleasant Lake, Benson County, 1912, *Lunell* (*R. deserta* Lunell); Little Missouri River, *Moyer 702.*

South Dakota: Missouri River, north of White River, *Hayden 254;* White River, *Stearns.*

Nebraska: Cheyenne County, *Rydberg 101.*

Kansas: Rawlins County, *Hitchcock 978a.*

23. Rosa terrens Lunell

This species differs from all the species of the *Cinnamomiae* of eastern North America in the stout prickles especially on the shoots. The prickles are fully as stout as those of the sweet brier. It is only known from the type collection.

24. Rosa Macounii Greene

It has been shown that the pubescent plant illustrated by Lindley in the Botanical Register under the name *R. Woodsii* has had a very confused nomenclatorial history. Watson thought it was the original *R. Woodsii* and stated that it was the same as *R. Maximiliani* Nees. At the time when I noticed the discrepancy in Lindley's treatments, I thought that Watson's statement was correct and adopted the name *R. Maximiliani* for the present species. The name was used in that sense in my

Flora of Colorado. Later I have had access to Prince Maximilian's Reise and found that the plant described there was the glabrous plant or the true *R. Woodsii.* In my Flora of Colorado I made another mistake, adopting the name *R. Macounii* for the glabrous plant, depending upon the impression I had received from Greene's rather vague description. After having seen Greene's type, though this does not represent the common form of the species as I know it, I came to the conclusion that the name *R. Macounii* should be adopted for the species here treated, being the oldest available name. *R. grosseserrata* E. Nelson was a mixture, but the type evidently belongs to the large-leaved form of this species not uncommon in the Central Rockies. *R. subunda* Lunell represents a depauperate form and *R. naiadum* the more common form of the plains and prairie region.

MINNESOTA: Montevideo, *Moyer 372.*

NORTH DAKOTA: Kuhn, La Mouse County, *Brenckle;* Minot, Lake Ibsen, Jamestown, Tower, and Butte, *Lunell* (without numbers).

SOUTH DAKOTA: Hermosa and Hotsprings (Black Hills), *Rydberg 677;* Wolf Creek, *Visher 2189;* Bear Creek, *Visher 2032;* Mobridge, *Moyer 691*, Big Stone Lake, *542*

NEBRASKA: Chadron, *J. M. Bates;* Lawrence Fork, *Rydberg 102;* Banner County, *Rydberg 98;* Hay Springs, *MacDougal 102;* Nattick, Thomas County, *Rydberg 1848.*

25. ROSA PYRIFERA Rydberg

This is a species of the Northern Rocky Mountains, first mentioned by Watson in a note under *R. Fendleri.*[*] It differs in the pear-shaped fruit and the more numerous, rather corymbose flowers. A few rather dubious specimens have been collected in the plains and prairie region. These have fruits which are inclined to be ellipsoid, rather than pyriform. Among them may be noticed.

SOUTH DAKOTA: Mobridge, *Moyer 688.*

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[*] Proc. Am. Acad. **20:** 345. 1885.

Sex reversal in the Japanese hop*

John H. Schaffner

(WITH PLATE 2)

After it became evident that abundant reversal of the sexual state takes place in *Cannabis sativa* L., when grown in the greenhouse during the short days of winter†, experiments were also made by the writer on *Humulus japonicus* Sieb. and Zucc., the Japanese hop. This hop is usually an annual, the vine growing from 10 to 30 feet long when planted in early May. It is a diecious plant much like the common hop, *Humulus Lupulus* L., but the carpellate catkins are not glandular. Both the inflorescence and the vegetative parts of the flowers show decided sexual dimorphism. The staminate inflorescence is a loose panicle and the staminate flower usually has three, four, or five distinct sepals with three, four, or five stamens and no vestige of a gynecium; while the carpellate inflorescence is an ament-like, large-bracted spike, and the carpellate flower has an entire sheath-like perianth surrounding the bicarpellate ovulary with no vestiges of stamens.

In recent years, both species of hop have been studied by Tournois‡ and by Winge.§ Both of these authors mention the occurrence of intermediate or monecious individuals in *Humulus*. Winge apparently obtained normal pollen from a monecious plant but does not state whether this plant was to be considered as staminate or carpellate. It is quite evident that in the hop, as in the hemp, the plants are originally determined as carpellate or staminate and the intermediate condition arises thru sex reversal during vegetative growth. Tournois reports 10 chromosomes in the gametophytes of both *H. Lupulus* and *H.*

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* Papers from the Department of Botany, The Ohio State University, No. 135.

† Schaffner, John H. Influence of environment on sexual expression in hemp. Bot. Gaz. **71**: 197–219. 1921.

‡ Études sur la sexualité du huoblon. Ann. Sci. Nat. Bot., **19**: 49–191. 1914.

§ The pollination and fertilization processes in *Humulus lupulus* L. and *H. japonicus* Sieb. et. Zucc. Compt. Rend. Trav. Carlsberg **11**: 1–44. 1914.

japonicus, but Winge is convinced that *H. Lupulus* has ten (haploid) and twenty (diploid) chromosomes and *H. japonicus* eight (haploid) and sixteen (diploid). He found no evidence of an allosome.

When Japanese hop is planted in the greenhouse in winter it becomes greatly dwarfed and the sexual state is much confused in a very large percentage of cases. Seed planted December 8th, 1920, in shallow benches produced twenty-two plants. They began to bloom in the sixth week after planting, some in exactly twenty-four days after coming out of the ground. The growth is considerably slower than in hemp under the same conditions. The plants usually have two or three pairs of leaves when they begin to bloom. Of the twenty-two plants raised in the winter of 1920–21, six were staminate and all showed reversal to the carpellate condition, i. e., they were staminate plants which produced carpellate structures from certain parts of their bodies. The carpellate structures appeared to be of all degrees of perfection. The remaining sixteen plants were carpellate and of these seven showed reversal to the male condition, producing staminate flowers or structures in various degrees of perfection, while nine remained pure carpellate and showed no sex reversal. Some of the carpellate intermediate individuals showed sex reversal at the beginning of blooming in the terminal inflorescence while others did not do so until a large number of typical carpellate inflorescences had been produced, and then only in axillary inflorescences developed at the base of the plant. One plant was especially remarkable in that it appeared to be pure carpellate in nature and had produced twelve normal carpellate inflorescences, when finally a tiny axillary cluster was developed near the base of the stem which showed one ovulary with a well-developed stamen at its base. No more staminate structures were found on this plant. Another decidedly carpellate plant developed thirty-six inflorescences and then produced a tiny cluster from near the base of the stem with several abnormal flowers. There were three stamens in the cluster. Other plants, both staminate and carpellate, produced numerous flowers or almost entire inflorescences of the opposite sexual state.

Although the staminate plants usually show sex reversal immediately, one plant remained pure in expression for a long time but finally developed a lower branch with a mixed inflorescence, several flowers showing imperfect ovularies and a number of well-developed stigmas. It is evident then, that reversal of sex varies both in the extent of the tissues involved and in the intensity or perfection of the given state. A large carpellate plant may produce but one imperfect stamen during its entire ontogeny and a staminate plant may show no sex reversal except the development of a single stigma on the entire individual. At the other extreme both kinds of individuals may produce perfect structures of the opposite sex. Some individuals show such a decided bisporangiateness that they sometimes have nearly equal numbers of the two kinds of structures in various degrees of perfection.

In hemp the general tendency appears in age to be towards maleness in both staminate and carpellate plants, altho some individuals are exceptional in this respect; but such a tendency was not evident to any extent in the Japanese hop except in a few individuals. The important factor in causing the reversal of the sexual state in the winter plants seems to be the greatly shortened period of daily illumination, and from other experiments it is probable that reversal takes place more readily if the plants are at the same time growing in a very rich soil, largely made up of well-rotted cow manure.

The nine carpellate plants which showed no reversal remained in the greenhouse until May when they were showing a decided rejuvenation and were planted out of doors where they continued to be pure carpellate.

The same kind of sex reversal was obtained in the winter of 1921–22, but the press of other experiments prevented a detailed study. No less remarkable than the reversal of the sexual state shown by the winter plants are the decided shortening of the vegetative period before anthesis and the great reduction in the size of the plant body. One extreme staminate intermediate plant had two cotyledons and two pairs of leaves and then ended in a small terminal inflorescence. There were flower clusters also in the axils of the cotyledons and the four leaves.

The accompanying plate represents a series of flowers to show in a general way the progressive change of sexual expression and the confusion which sometimes occurs in the stamens and ovularies. The examples, however, do not by any means represent the diversity of floral structure to be found. Such confusion in character expression is quite generally present whenever the change from one sexual condition to the other takes place on a developing monecious inflorescence axis or when two tissues of opposite sexual state meet at a point predestined by its position to give rise to a flower, as shown by the writer elsewhere.*

FIG. 1 represents a typical staminate flower from a staminate plant and FIGS. 2–12 represent a series of flowers and flower parts taken from staminate plants with sex reversal. They show how one can find all stages of transition and confusion in the sexual expression. Stamens may develop stigmas (FIGS. 2, 3, 6), ovularies may give rise to microsporangia (FIGS. 5, 9, 10, 11), and normal or nearly normal stamens and ovularies may develop in the same flower (FIG. 8).

FIG. 13 represents a typical carpellate flower from a carpellate plant, and FIGS. 14–22 represent a series of flowers from carpellate intermediate plants showing various types of sex mosaics up to the normal staminate flower in FIG. 22. Just as in the reversed flowers from the staminate plants there are here striking cases of sex tissue mosaics. FIGS. 14 and 15 represent ovularies with stamens developing from their sides. The ovulary in FIG. 15 has but one stigma. FIG. 17 represents an ovulary with two microsporangia near the top, and FIGS. 20 and 21 imperfect carpel-stamen complexes in decidedly staminate flowers.

As stated before, such examples could be extended indefinitely, each one showing some rather prominent example of peculiar sexual expression. The development of these complex sex mosaics is due to the disturbances brought about by the abnormal environmental conditions, probably largely through a disturbed metabolism, which causes one cell or cell complex to be thrown into the male state while the neighboring cells remain in the female state, or vice versa. It seems clear that the more recent notions in regard to sex will need to be revised and restated in agreement with actually ascertained experimental evidence. The notion that sexuality is primarily hereditary in nature and Mendelian will have to be abandoned. It clearly does not appear

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* Reversal of the sexual state in certain types of monecious inflorescences. Ohio Jour. Sci. **21**: 185–200. 1921.

to be a matter of nuclear and chromosome morphology. The next steps are perhaps now possible—to ascertain something of the real nature of sexuality and a more definite knowledge of sex control in favorable plants. It appears to the writer that this must, to some extent at least, lead into the fields of ionization in chemistry and electrons and electricity in physics; in other words the biological phenomena of sex are probably fundamentally physico-chemical and not morphological.

CONCLUSION

From the results of the experiments with *Humulus japonicus* and other plants, it is evident that dieciousness with its accomppanying sexual dimorphism is not due to the absence in either the staminate or carpellate individual of a complete set of hereditary factors for the expression of all the sexual characters, both male and female; nor is the monosporangiateness of the normal individual due to the presence of a homozygous or heterozygous condition of any kind of hereditary sex determination whatsoever, which might be assumed to gain or lose domiinance at the time of the reversal of the sexual state; for, as shown in the preceding discussion, all of the staminate plants changed to a greater or less extent to femaleness and nearly half of the carpellate plants showed reversal to maleness by simply subjecting them to an unusual environment.

Those who are seeking an explanation of sex in terms of homozygous and heterozygous conditions of the male and female individuals are following a delusion obtained from an incomplete knowledge of the phenomena of sexuality as exhibited in the plant kingdom; for it is evident that gametophytes are haploid organisms and so cannot have their factors or chromosomes in a yoked condition, yet males, females, and hermaphrodites, and reversals of the given sexual states occur side by side in homosporous plants, including liverworts, mosses, hornworts, ferns, lycopods, and horsetails. In heterosporous sporophytes, bisporangiate individuals including the monecious species are the rule, and the diecious species represent only specialized conditions in respect to the sexual state; so here also, although the organism is diploid, the dieciousness is not at all caused by homozygous and heterozygous factors or chromosomes which control the sexual state, since both individuals can be caused to change to the opposite condition in the vegetative phase of development, both naturally and through experimental means, the male to the female and the female to the male.

The sexuality of cells, tissues, organs, and individuals is due to some state or condition, apparently related to chemico-electrical phenomena, which arises in the cell units at certain stages of the ontogeny and gives a peculiar character, either male, female, or neutral, to the materials and structures produced through the operation of the hereditary factors present. It is probable that the identical factors may give rise to characters which we recognize as male or female; at least both kinds of structures arise in the same organs or tissues, side by side, which would under the usual expression be purely male or purely female.

COLUMBUS, OHIO

Explanation of plate 2

All the figures are slightly magnified.

FIG. 1. Staminate flower from staminate plant.

FIG. 2. Confused flower from staminate plant.

FIG. 3. From staminate plant. A central staminate structure with a stigma, the upper part of the stigma is destitute of stigmatic hairs. This flower had four normal stamens and five sepals.

FIG. 4. Flower from lower branch of decidedly staminate plant, showing imperfect ovulary with one stigma.

FIG. 5. Central ovulary with one stigma and an imperfect anther with two microsporangia growing out of the side near the top. The flower had four sepals and five normal stamens. Staminate plant.

FIG. 6. Flower from staminate plant with two stamens without stigmas but one with an ovulary-like outgrowth at the base, and with a central stamen-carpel complex.

FIG. 7. Flower from a staminate plant with three sepals, three stamens, and a central imperfect ovulary with one long and one short stigma.

FIG. 8. Flower from staminate plant, with one nearly perfect gynecum and one stamen.

FIG. 9. Confused carpellate flower from a staminate plant, the ovulary with three stigmas, the smaller one having a microsporangium at its base.

FIG. 10. An ovulary-like structure ending in a stigma and with microsporangia on opposite sides. From staminate plant.

FIG. 11. An ovulary with one prominent stigma and with a stamen growing out from its side. From staminate plant.

FIG. 12. A nearly perfect carpellate flower from a staminate plant. The perianth sheath is split down on one side instead of being continuous.

FIG. 13. A typical carpellate flower from a carpellate plant.

FIG. 14. Carpellate flower from carpellate plant, with a stamen growing out from near the base of the ovulary.

FIG. 15. An ovulary with one stigma and one stamen from near the base, from carpellate plant.

FIG. 16. A flower from a carpellate plant showing a stamen with a slight development of a stigma and a stamen-like ovulary with two stigmas.

FIG. 17. A carpellate flower from a carpellate plant, the ovulary with two abnormal stigmas and with two microsporangia near the top.

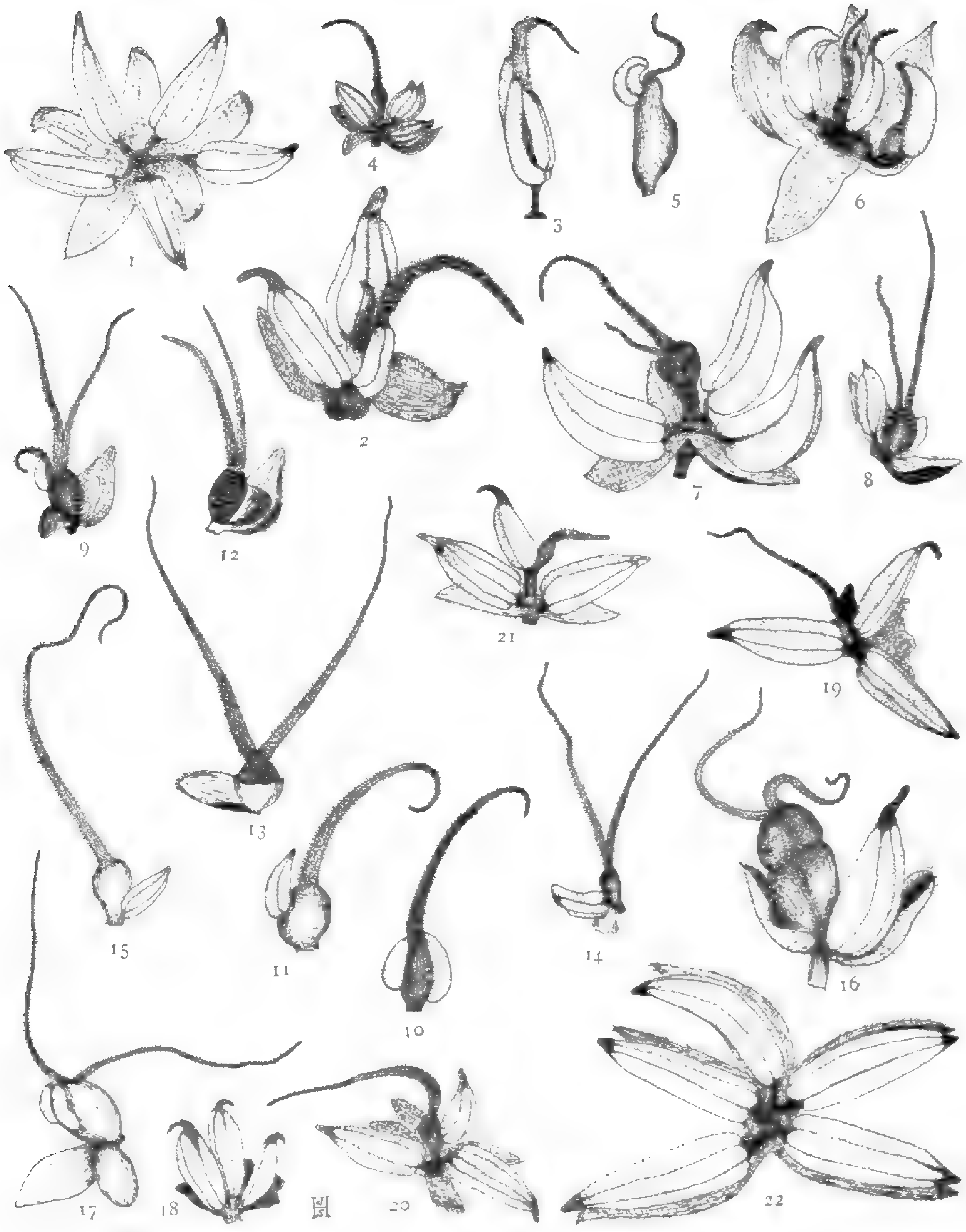
FIG. 18. A staminate flower from a carpellate plant. Each of the three stamens showing a rudimentary stigma. The perianth, a continuous, toothed structure, is cut open to expose the stamens properly.

FIG. 19. Flower from a carpellate plant, with three stamens, one growing from the side of the imperfectly developed ovulary showing a small stigma.

FIG. 20. Flower from a carpellate plant, with 4 sepals, two stamens and an imperfect ovulary with a stamen developed at its side and one stigma at the tip.

FIG. 21. A flower from a carpellate plant, showing two stamens and a central stamen-carpel complex.

FIG. 22. A perfect staminate flower from a carpellate plant.



SCHAFFNER: SEX REVERSAL IN JAPANESE HOP

What is Geranium caespitosum James?

GEO. E. OSTERHOUT

From the time when *Geranium caespitosum* was first published in 1825, when geraniums were few, till the present time, when they are many, there has been an uncertainty as to what species should have the name.

On July 6, 1820, at about noon, the Long Expedition, of which Dr. Edwin P. James was botanist, surgeon and geologist, and of which he became historian, went into camp on the bank of the South Platte, where it issues from the mountains. This is about fifteen miles from Denver, Colorado. Dr. James notes in considerable detail the rock formations about the camp. "The woodless plain," he says, "is terminated by a range of naked and almost perpendicular rocks, visible at a distance of several miles, and resembling a vast wall, parallel to the base of the mountains. These rocks are sandstone . . . About the sandstone ledges we collected a geranium intermediate between the cranes-bill and the herb-robert." I quote from the London edition of Dr. James's "Account" of the Expedition, which was published in 1823. At the end of Vol. II, among the appended notes, is the following description of the *Geranium*: "Geranium intermedium, I.—Caespitose, sub-erect, pubescent, sparingly branched above. Radical leaves reinform deeply $\frac{5}{9}$ cleft. The flower is a little larger than that of G. robertianum, and similarly coloured, having whitish lines toward the base of the corolla." There is only one *Geranium* mentioned. It may be noticed that the description is short and so indefinite that it might be applied to several species of *Geranium*."

The critical species of Dr. James's collection were submitted to Dr. John Torrey for examination and publication, and the notable and new species were published in 1826, in the Annals of the Lyceum of New York, volume II. On page 173 we have, "Geranium caespitosum James, in Long's Exped. ii. p. 3," and the description substantially as quoted above. Dr. Torrey remarks: "There are no specimens of this plant in the collection. Found on the sandstone ledges at the base of the Rocky Mountains." Dr. Torrey quotes from the American edition of Dr.

James's "Account," which was published in 1825, or two years later than the London edition. The name of the *Geranium* is changed from *G. intermedium* to *G. caespitosum.*

The basis of our present understanding of *G. caespitosum* James is Dr. Asa Gray's description in "Plantae Fendlerianae," p. 25. Dr. Gray was instrumental in sending out Professor Augustus Fendler with an army company, in 1846, to Santa Fe, New Mexico, and the collections on which the description is based were made by Fendler, in 1847, "on Santa Fe Creek, near irrigating ditches, at the foot of mountains; May to July; and six miles east of the Mora River: August." Of this *Geranium* Dr. Gray gives a clear and carefully made description and says: "Dr. Engelmann had indicated it as a new species; but I am so confident that it is the species noticed and imperfectly characterized by Dr. James that I venture to revive his name, which unless thus identified, must ever remain appended to the genus as a doubtful species, since no specimen of it exists in the collection made by him in Long's Expedition."

In 1897, fifty years after Professor Fendler's collection, Professor A. A. Heller and Mrs. Heller collected plants about Santa Fe, and along Santa Fe Creek collected a *Geranium*, which Professor Heller published in 1898 as *G. atropurpureum*,* and he made this new species to take the place of Dr. Gray's publication, saying that the *Geranium* which Dr. Gray published was not *G. caespitosum* James. In his article Professor Heller says: "All the evidence seems to indicate that the real *Gerauinm caespitosum* is the plant now known as *Geranium Fremontii*, at least so far as applies to the plant collected by Fremont. What Fendler's specimens from 'bottom lands of the Mora river' and Lieutenant Abert's from the 'Raton Mountains' [plants cited in the original description] may be, I do not know, but they are hardly the same as Fremont's specimens, and apparently different from *G. atropurpureum*." However, the type of *G. Fremontii* Torr., as published by Dr. Torrey in "Plantae Fendlerianae," page 26, was collected in the vicinity of Santa Fe by Professor Fendler. Of course it may not be identical in character with the plant collected by Fremont in the Black Hills, in 1842, as listed in the "Catalogue of Plants collected by Lieutenant

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* **Bull. Torrey Club 25: 195. 1898.**

Fremont in his Expedition to the Rocky Mountains." This plant was listed by Dr. Torrey in the catalogue as a "n. sp." and given the name *G. Fremontii*, but I do not know of any description of it. Professor Heller failed to note the exact locality where Dr. James collected *G. caespitosum*, though he quotes from Dr. James's description of the rocks and character of the country, and writes: "At this place, 'about the sandstone ledges,' is where he collected his *Geranium*, either in what is now the State of Nebraska, or at most, in extreme northeastern Colorado." Professor Heller also said that Dr. James did not go farther south than Pike's Peak, which, of course, is a mistake.

The recent makers of Rocky Mountain Floras differ in their treatment of the geraniums and in their disposition of *G. caespitosum*. Dr. Trelease* accepts Dr. Gray's identification of it with the Santa Fe plant and gives its range as "Arizona, New Mexico, and southward." Dr. Nelson† accepts Dr. Gray's conclusion and makes *G. atropurpureum* Heller a synonym. He gives its range as "Central Colorado but occasionally north to Wyoming and south to New Mexico." Dr. Rydberg‡ accepts *G. atropurpureum* Heller and for *G. caespitosum* James makes a description much like Dr. Gray's. He describes it as being found on "Plains, foot-hills, and the lower mountains: Colo.— Wyo.— Utah."

It is evident that the place to look for *Geranium caespitosum* James is the place where Dr. James collected it; that is, "about the sandstone ledges," where the Long Expedition camped from July 6 to July 9, 1820. This place is so definite and so restricted that one looking for it can not miss it. "Our camp," wrote Dr. James, "was immediately in front of the chasm, through which the Platte issues from the mountains." On account of the rocky and hilly nature of the country the place has not been cultivated, and is in much the same condition as it was in 1820. Among the ravines of the sedimentary rocks a *Geranium* grows abundantly and luxuriantly. It is *G. Fremontii* var. *Parryi* Engelm., more lately known as *G. Parryi* (Engelm.) Heller, and is the only *Geranium* found in the immediate vicinity. The reason why *G. Parryi* has not been associated with *G. caespito-*

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* Syn. Fl. N. Am. **1:** 359. 1897.

† Coulter & Nelson, New Man. Bot. Rocky Mt. 303. 1909.

‡ Fl. Rocky Mts. 533. 1917.

sum, probably, is that Dr. Gray's solution of the problem has been largely accepted, and that the type locality of *G. Parryi* is some distance from, and at a much higher altitude than, the place where *G. caespitosum* was collected. The type locality of the former is, "from the head waters of Clear Creek and the alpine ridges lying east of 'Middle Park,' Colorado Territory. C. C. Parry, coll., 1861." It is one of those plants whose range is from the foothills to the high mountains. The localities where it has been collected, as listed by Dr. Rydberg in his Flora of Colorado, include Boulder, Colorado Springs, Idaho Springs, Pike's Peak, and the head waters of Clear Creek.

There can be scarcely a doubt that the same *Geranium* has continued to grow "about the sandstone ledges" from the time when Dr. James collected it to the present time; and, granting that this is so, *G. atropurpureum* Heller is all right, but *G. caespitosum* or, since the law of priority should hold, *G. intermedium* James should take the place of *G. Parryi* (Engelm.) Heller, and the latter become a synonym.

WINDSOR, COLORADO

Abnormal elaters of Porella platyphylla

F. M. ANDREWS

(WITH PLATE 3)

In 1908 the writer* described and illustrated an archegonium of *Porella platyphylla* having two egg-cells, two ventral canal cells, and two rows of canal cells, therefore forming two complete axial rows instead of the usual one row. The elaters also were abnormal in that they were branched, in one case slightly and in another to a considerable extent.

In 1914 Manning† reported another case of an archegonium of *Porella platyphylla*, similar to the one above referred to. These abnormal archegonia coincide with the idea of Davis‡ concerning the origin of the archegonium. In *Mnium* also Coker§ found an archegonium containing two egg-cells, which, however, were superposed. More than one row of canal cells have been noted in the archegonium of *Mnium cuspidatum* by Holferty;|| Pace¶ has observed two adjacent archegonia in the prothallia of a fern with no wall between the egg-cells; and Lyon** has recorded other peculiarities in the archegonia of certain pteridophytes.

The present account deals with some unusual forms of the elaters in *Porella platyphylla*.†† While studying some material of this plant which was collected near Bloomington, Indiana, the writer observed that a few of the capsules contained a number of abnormal elaters, although nearly all of those examined were of the usual shape. Some of the abnormal elaters were kept for a time on the slide and not mounted permanently, so as to

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* An abnormal *Porella platyphylla*. Bot. Gaz. **45:** 340. *f. 1–3.* 1908.

† Life history of *Porella platyphylla*. Bot. Gaz. **57:** 320–323. *pl. 15, 16.* 1914.

‡ The origin of the archegonium. Ann. Bot. **17:** 477–492. *f. 21, 22.* 1903.

§ On the occurrence of two egg cells in the archegonium of *Mnium*. Bot. Gaz. **35:** 137. *f. 2.* 1903.

|| The archegonium of *Mnium cuspidatum*. Bot. Gaz. **37:** 106–126. *pl. 5, 6.* 1904.

¶ Bot. Gaz. **50:** 52. 1910.

** Bot. Gaz. **37:** 282–285. 1904.

†† For a consideration of *Porella platyphylla* and *P. platyphylloidea* see Müller in Rabenhorst's Kryptogamen-Flora **62:** 573, 581. 1915. Also Evans, Rhodora **18:** 74–85; 103–119. 1916.

ascertain their behavior when in dry or moist air. Many of the elaters branched, as was shown in my former account, but in the elaters here being considered the branching was more extensive. In one case an elater had sent out two branches from the sides, FIG. 1, so as to give rise to four prongs or divisions. In another case, FIG. 2, the original elater, A, had produced three branches, B, C and D, of different lengths; and the branch D had again produced a short branch E, so that the elater then had six branches.

Peculiarities were also observed in the number of spiral thickenings of the elaters. In a few of the elaters only one spiral was present, but generally there were two. Underwood* states that the number varies from two to three. FIG. 3 is given here in order to show how the spiral thickenings are often torn away from the wall of the elater by handling. Macvicar† states that the spiral bands vary in some species from two to four. In most of the elaters observed, from the specimens under consideration here, the number of spiral thickenings was two in the unbranched elaters. A good many of the unbranched elaters showed three spiral thickenings (FIG. 3), which extended the entire length of the elater. In many cases they extended only part way from the center. In quite a number of instances the elater possessed four full length spirals (FIG. 4), and several had five such thickenings (FIG. 5). A few others had six (FIG. 6), and one very short, more or less reniform, elater showed ten spiral thickenings (FIG. 7). The last elater was so short and thick as scarcely to resemble in shape the general form of ordinary elaters, and the numerous crossing bands were difficult to observe separately and to follow. As regards its shape the elater shown in FIG. 7 somewhat resembles the "*verrucosa*" form of elater described by Macvicar‡ for *Fossombronia caespitiformis*, which has from three to five spirals. As above mentioned under FIG. 3 and shown also in FIGS. 1 and 5 the spiral bands are more or less extensively torn away from the wall of the elater. The form of the simple or unbranched elaters is sometimes rather unusual, as in the case of FIG. 7;

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* Gray, Man. Bot. Ed. 6, 708. 1889.

† Student's Handb. British Hep. 402. 1912.

‡ Op. cit. 83.

this holds true also for others, as in FIG. 6, and in some cases the elater approaches a more or less conical shape, the broad end of which is nearly flat. Even in the simple elaters the spiral thickenings do not always run the entire length of the elater. This is likewise true of some of the branched elaters and can be noticed to a certain extent in the supernumerary spiraled elaters shown in FIGS. 5 and 6. In the branched elaters shown in FIGS. 1 and 2, some of the branches show two spiral thickenings while others show three. The elaters of *Targionia hypophylla* frequently branch; in the example figured by Müller* two spirals are shown in one prong and three in another. The short elaters with supernumerary spirals evidenced a less active movement when placed in dry and moist air alternately than the longer and more slender elaters.

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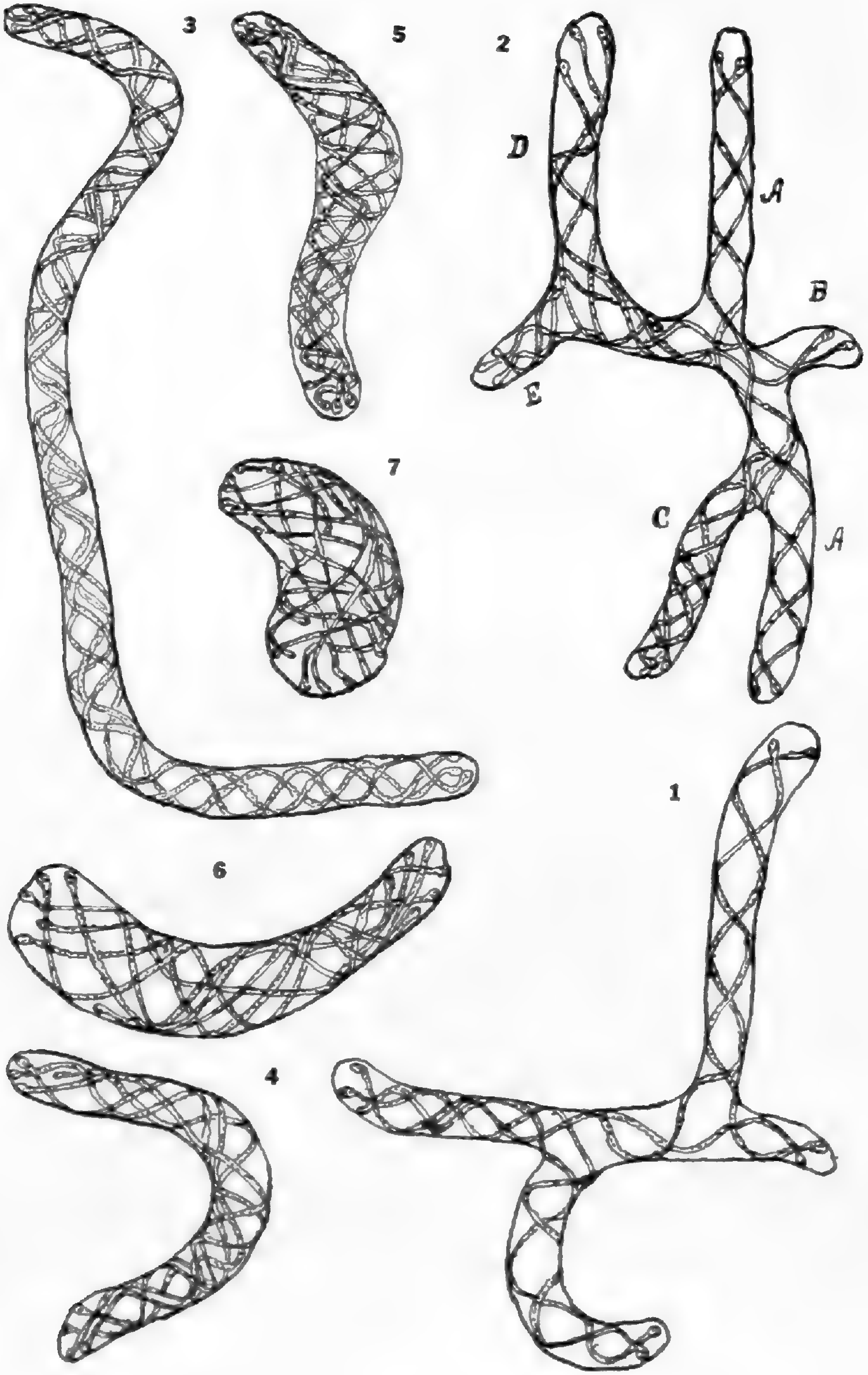
* Rabenhorst's Kryptogamen-Flora **6**: 231. *f. 146.* 1907.

Explanation of plate 3

ABNORMAL ELATERS OF PORELLA PLATYPHYLLA

All figures × 300.



ANDREWS: ABNORMAL ELATERS OF PORELLA

INDEX TO AMERICAN BOTANICAL LITERATURE

1921-1922

The aim of this Index is to include all current botanical literature written by Americans, published in America, or based upon American material; the word America being used in the broadest sense.

Reviews, and papers that relate exclusively to forestry, agriculture, horticulture, manufactured products of vegetable origin, or laboratory methods are not included, and no attempt is made to index the literature of bacteriology. An occasional exception is made in favor of some paper appearing in an American periodical which is devoted wholly to botany. Reprints are not mentioned unless they differ from the original in some important particular. If users of the Index will call the attention of the editor to errors or omissions, their kindness will be appreciated.

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Fernald, M. L. *Lysimachia terrestris* (L.) BSP., var. *ovata* (Rand & Redfield) n. comb. Rhodora **24**: 76. 20 Je 1922.

Fernald, M. L. Notes on *Sparganium*. Rhodora **24**: 26-34. 23 My 1922.

Fernald, M. L. Variations of *Cakile edentula*. Rhodora **24**: 21-23. 23 My 1922.

Folsom, D. Potato leafroll. Maine Agr. Exp. Sta. Bull. **297**: 37-52. *f. 29-35*. Ap 1921.

Gardner, M. W., & Kendrick, J. B. Overwintering of tomato mosaic. Bot. Gaz. **73**: 469-485. *pl. 17*. Je 1922.

Garner, W. W., & Allard, H. A. Photoperiodism, the response of the plant to relative length of day and night. Science II. **55**: 582, 583. 2 Je 1922.

Garratt, G. A. Poisonous woods. Jour. For. **20**: 479-487. My 1922.

Gray, F. W. Scores of stations for *Gaylussacia brachycera* in West Virginia. Torreya **22**: 17, 18. Mr-Ap 1922.

Grier, N. W. The mosses of Washington County, Pennsylvania. Bryologist **25**: 9-12. 27 Ap 1922.

Grout. A. J. *Brachythecium* notes. Bryologist **25:** 13, 14. 27 Ap 1922.

Includes *B. Holzingeri* comb. nov. and *B. oxycladon falcata* forma nov.

Gunderson, A. The evolution group at the Brooklyn Botanic Garden. Brooklyn Bot. Gard. Leaflets **10:** 1–4. *f. 1–14.* Je 1922.

Guthrie, J. D. Notes on the forests of Rumania. Jour. For. **20:** 513–520. My 1922.

Hall, A. F. The forests of the Roosevelt-Sequoia National Park. Natural History **22:** 169–174. Mr–Ap 1922. [Illust.]

Hall, E. H. Sulphur and nitrogen content of alfalfa grown under various conditions. Bot. Gaz. **73:** 401–411. My 1922.

Harvey, R. B. Varietal differences in the resistance of cabbage and lettuce to low temperatures. Ecology **3:** 134–139. *f. 1–6.* 26 Ap 1922.

Hazen, T. E. The phylogeny of the genus *Brachiomonas.* Bull. Torrey Club **49:** 75–92. *pl. 3, 4 + f. 49, 50.* 18 My 1922.

Includes *B. simplex* sp. nov.

Hazen, T. E. New British and American species of *Lobomonas:* a study in morphogenesis of motile algae. Bull. Torrey Club **49:** 123–140. *pl. 5, 6.* 15 Je 1922.

Includes *L. pentagonia* and *L. rostrata* spp. nov.

Hedgcock, G. G., & Hahn, G. G. Two important pine cone rusts and their new cronartial stages. Phytopathology **12:** 109–122. *pl. 5, 6.* 6 Je 1922.

Heimlich, L. F. Peloria in *Linaria* and other plants. Proc. Indiana Acad. Sci. **1921:** 111–116. *f. 1–12.* 1922.

Heimlich, L. F. Plants of White County [Indiana]—IV. Proc. Indiana Acad. Sci. **1921:** 117–119. 1922.

Hitchcock, A. S. Grasses of British Guiana. Contr. U. S. Nat. Herb. **22:** 439–514. *pl. 53 + f. 77–86.* 1922.

Hitchcock, A. S. A perennial species of teosinte. Jour. Washington Acad. Sci. **12:** 205–208. 19 Ap 1922.

Euchlaena perennis sp. nov.

Hoem, T. Studies in the Cyperaceae—XXXIV. Am. Jour. Sci. V. **3**: 260–268. *f. 1–14.* Ap 1922.

Holzinger, J. M. *Grimmia Brandegei* Aust. Bryologist **25**: 16, 17. 27 Ap. 1922.

Hopkins, E. F. Varietal susceptibility of the yellow bell-flower apple to cedar rust. Phytopathology **12**: 190–191. *f. 1.* 29 Je 1922.

Hosseus, C. C. Flora Argentina.—estudios comparativos sobre la vegetacion de las provincias de la Rioja y de San Juan. Bol. Acad. Nac. Cien. Cordoba **26**: 5–160. *f. 1–28.* 1921.

Hungerford, C. W. Leafroll, mosaic and certain other related diseases in Idaho. Phytopathology **12**: 333–139. *pl. 9.* 6 Je 1922.

Illick, J. S. The birches. Am. For. **28**: 355–364. Je 1922. [Illust.]

Jackson, H. S. New or noteworthy rusts on Carduaceae. Mycologia **14**: 104–120. 6 Je 1922.

Includes 5 new species in *Puccinia.*

Jeffrey, E. C., Longley, A. E., & Penland, C. W. T. Polyploidy, polyspory, and hybridism in the angiosperms. Science **55**: 517, 518. 12 My 1922.

Jones, L. H., & Shive, J. W. Influence of wheat seedlings upon the hydrogen ion concentration of nutrient solutions. Bot. Gaz. **73**: 391–400. My 1922.

Judd. C. S. Chaulmoogra oil plantation. Hawaiian For. & Agr. **19**: 65, 66. Mr 1922. [Illust.]

Kaiser, G. B. Little journeys into mossland—VI. The mosses of tree-trunks. Bryologist **25**: 14–16. 27 Ap 1922.

Killip, E. P. New passifloras from Mexico and Central America. Jour. Washington Acad. Sci. **12**: 255–262. 4 Je 1922.

Includes 11 new species.

Kincer, J. B. The relation of climate to the geographical distribution of crops in the United States. Ecology **3**: 127–133. 26 Ap 1922.

Kirby, R. S. The take-all disease of cereals and grasses. Phytopathology **12:** 66–88. *pl. 2–4* + *f. 1–3.* 25 Ap 1922.

Kraebal, C. J. Mauna Kea plant list. Hawaiian For. & Agr. **19:** 2–4. My 1922.

Krauch, H. The intolerance of western yellow pine regarded as a regulating factor in the maintenance of the type. Jour. For. **20:** 463, 464. My 1922.

Lee, H. A. Banana freckle in the Phillippine Islands. Phytopathology **12:** 101, 102. *f. 1.* 25 Ap 1922.

Long, B. Occurrence of *Botrychium matricariaefolium* in New Jersey. Am. Fern Jour. **12:** 1–9. 15 Je 1922.

Ludwig, C. A. The growth of tree twigs. Proc. Indiana Acad. Sci. **1921:** 121–131. 1922.

Lupo, P. Stroma and formation of perithecia in *Hypoxylon.* Bot. Gaz. **73:** 486–495. *pl. 18* + *f. 1–7.* Je 1922.

Lyon, C. J. A phaenological study in New England. Torreya **22:** 19–28. Mr–Ap 1922.

Macbride, T. H. The North American slime molds. Revised edition. pp. 1–340. *pl. 1–23.* New York. 1922.

Macht, D. I., & Livingston, M. B. Effect of cocaine on the growth of *Lupinus albus.* A contribution to the comparative pharmacology of animal and plant protoplasm. Jour. Gen. Physiol. **4:** 573–584. 20 My 1922.

Mains, E. B. Evidence of the seed carriage of the *Euphorbia* rusts, *Uromyces proeminens* and *U. dictosperma.* Proc. Indiana Acad. Sci. **1921:** 137–139. 1922.

Mains, E. B. Observations concerning *Puccinia Pattersoniana* and *Puccinia Moreniana.* Proc. Indiana Acad. Sci. **1921:** 133–135. *pl. 1.* 1922.

Marsh, C. D., & Clawson, A. B. The death camas species, *Zygadenus paniculatus* and *Z. elegans,* as poisonous plants. U. S. Dept. Agr. Bull. 1012: 1–25. *pl. 1–3* + *f. 1–5.* 17 Ap 1922.

Marshall, M. A. Reminiscences of a fern lover. Am. Fern Jour. **12:** 16–19. 15 Je 1922.

Mattfeld, J. Zwei neue Orobanchen aus Peru. Notizbl. Bot. Gart. u. Mus. Berlin-Dahlem **8:** 182–186. 1 Ap 1922.

Includes *O. Weberbaueri* and *O. tacnaensis*, spp. nov.

Medsger, O. P. Goldie's fern (*Dryopteris Goldieana*). Torreya **22:** 50. Je 1922.

Meier, F. C., Drechsler, C., & Eddy, E. D. Black rot of carrots caused by *Alternaria radicina* n. sp. Phytopathology **12:** 157–166. *pl. 11 + f. 1, 2.* 29 Je 1922.

Moore, B., & Taylor, N. Plant composition and soil acidity of a Maine bog. Ecology **2:** 258–261. 26 Ap 1922.

Munns, E. N. Reproduction and nitrogen. Jour. For. **20:** 497, 498. My 1922.

Munz, P. A. & Johnston, I. M. Miscellaneous notes on plants of Southern California—I. Bull. Torrey Club **49:** 31–44. 4 Ap 1922.

Includes *Pentstemon Munzii* Johnston sp. nov.

Murrill, W. A. Dark-spored Agariso—II. *Gomphidiusa* and *Stropharia.* Mycologia **14:** 121–142. 6 Je 1922.

Includes 4 new species.

Neller, J. R. The influence of growing plants upon oxidation processes in the soil. Soil Sci. **13:** 139–159. *pl. 1 + f. 1.* Mr 1922.

Nelson, J. C. Introduced species of *Lathyrus* in the northwest. Rhodora **24:** 75, 76. 20 Je 1922.

Ness, H. Breeding work with blackberries and raspberries. Jour. Heredity **12:** 449–454. *f. 10–12.* D 1921.

Nichols, G. E. The bryophytes of Michigan with particular reference to the Douglas Lake region. Bryologist **25:** 41–58. 22 My 1922.

Nichols, S. P. Methods of healing in some algal cells. Am. Jour. Bot **.9:** 18–27. *pl. 3.* 21 F 1922.

Packard, W. Our vanishing wild flowers. Am. For. **28:** 293–299. My 1922. [Illust.]

Payson, E. B. Species of *Sisymbrium* native to America north of Mexico. Univ. Wyoming Publ. Sci. **1:** 1–27. 15 Je 1922.
Describes *S. juniperorum* sp. nov.

Payson, E. B. A synoptical revision of the genus *Cleomella.* Univ. Wyoming Publ. Sci. **1:** 29–46. 15 Je 1922.
Includes *C. Macbrideana* and *C. mojavensis,* spp. nov.

Peattie, D. C. Coastal plain element in flora of Great Lakes. Rhodora **24:** 57–70. *f. 1–5.* 20 Je 1922.

Pennell, F. W. Scrophulariaceae of the West Gulf States. Proc. Acad. Nat. Sci. **73:** 459–536. 1922.
Includes 10 new species, 5 new varieties and 7 new combinations.

Perry, W. J. A word for the lowly pinon. Jour. For. **20:** 521–526. My 1922.

Piper, C. V., & Carrier, L. Carpet grass. U. S. Dept. Agr. Farmers' Bull. 1130: 1–12. *f. 1–5.* Ap 1922.

Poole, R. F. Celery mosaic. Phytopathology **12:** 151–154. *pl. 10 + f. 1.* 6 Je 1922.

Pritchard, F. J., & Porte, W. S. *Isaria* rot of tomato fruits. Phytopathology **12:** 167–172. *pl. 12 + f. 1.* 29 Je 1922.

Raines, M. A. Vegetative vigor of the host as a factor influencing susceptibility and resistance to certain rust diseases of the higher plants. Am. Jour. Bot. **9:** 215–238. *pl. 11, 12.* 21 Je 1922.

Randolph, L. F. Cytology of chlorophyll types of maize. Bot. Gaz. **73:** 337–375. *pl. 11–16.* My 1922.

Robbins, W. J. Cultivation of excised root tips and stem tips under sterile conditions. Bot. Gaz. **73:** 376–390. *f. 1–4.* 16 My 1922.

Rosen, H. R. *Tilletia texana* in Missouri. Ann. Missouri Bot. Gard. **8:** 357–359. N 1921.

Vol. 50 No. 3

BULLETIN

OF THE

TORREY BOTANICAL CLUB

MARCH, 1923

Polyembryony developed under experimental conditions in certain polypodiaceous ferns

AUSTIN ETTER

(WITH PLATE 4 AND SEVEN TEXT FIGURES)

Among liverworts and in many mosses, polyembryony, or the development of two or more sporophytes upon a single gametophyte, is the rule rather than the exception. Among the Pteridophytes, however, the phenomenon is of less frequent occurrence.

While experimenting with prothallia by lighting them both above and below, Heinricher secured two perfect embryos on one prothallium, one above and one below. The value of this as an example of polyembryony was questioned by Atkinson ('93) in that it might be considered an abnormal case.

As stated by Atkinson ('93), "Rauwenhoff ('89) notes the development of two embryos on single prothallia of *Gleichenia*. In both of these cases, however, we are not informed of the comparative strength or advanced condition of growth of the embryos, so that it may be an open question whether both of the embryos on a single prothallium could have developed into independent plants." In at least one other instance, however, Rauwenhoff ('91) described and figured, according to Buchholz ('22, p. 263), polyembryony in *Gleichenia*, indicating the relative size and condition of the two embryos.

During his study of *Osmunda*, Campbell ('92) observed two embryos on one prothallium, one of which was much smaller

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[THE BULLETIN for February (**50**: 60–94. *pl.* 2, 3) was issued February 23, 1923.]

than the other and would probably have been starved out by the larger one before it could have become independent of the gametophyte.

Farmer ('92), while working out the embryogeny of *Angiopteris evecta*, observed and figured a prothallium bearing two young sporophytes, widely separated and perhaps located on two different archegonial cushions.

Atkinson ('93) reported a case of "two independent plants from the same prothallium" in *Adiantum cuneatum*.

In *Botrychium Lunaria* Bruchmann ('06) found that, in several prothallia examined, two embryos had started to develop, but in no instance were three found on one gametophyte.

A number of large sporophytes and embryos were found by Lang ('14) in single *Helminthostachys* prothallia. Most of the embryos were small and aborted when found on prothallia with larger successful plants. He further observed that a number of archegonia must have been fecundated simultaneously in a few cases of prothallia which were attached to young sporophytes.

Jeffrey ('98) during his work on *Botrychium virginianum* observed in one instance two sporophytes on a single prothallium.

Campbell ('21, p. 147) found in *Botrychium obliquum* that one-celled embryos were common, as several archegonia may be fecundated and begin to form embryos, the inference being that two or more unicellular embryos were seen on a single prothallium.

Czaja ('21, p. 565) succeeded in four out of six attempts in causing two embryos to develop on one prothallium of *Gymnogramme chrysophylla*, and observed that both embryos of a single prothallium developed almost equally, but stated that these facts were not at all surprising since they were borne on old vigorous prothallia with large archegonial cushions.

In a species of *Aspidium*, probably *Aspidium Thelypteris*, collected in its natural habitat, Buchholz ('22, *f. 24*) illustrates the occurrence of plural embryos. Two embryos were figured on a single prothallium, one of which had approximately 25–30 cells; the other one was unicellular and was located about 1 mm. back of the sinus on the remote side of the archegonial cushion. He also illustrates (*l.c., f. 25*) what he believes to be a slightly later stage indicating the fate of the smaller embryo. The larger embryo (*l.c., f. 25A*) in this case had apparently attained a size of approximately 300–400 cells; while, in his *f. 25B*, is shown what he believes to be a unicellular embryo, with disintegrating nucleus, collapsing, as it seems to have been aborted through embryonic competition. This might have been only an old egg-cell disintegrating. The venter indicates no decided development as should be expected in the presence of a zygote. If this, however, is a unicellular embryo, three or four, and probably more, have been observed by me during this study on the same gametophyte along with one or two other larger embryos.

In preparing demonstrations for class use observers have noted the occurrence of two or three and possibly four embryos per gametophyte, but embryos that had reached the stage with the first leaf evident were not reported. When small embryos were observed along with a much larger embryo on the same prothallium, it was noted that the smaller ones were evidently suffering from the competitive struggle, as was apparent by the shrunken appearance of the cells (see Buchholz, '22, p. 264).

Goebel ('87) reported the occurrence of several embryos on individual prothallia of *Vittaria*, some of which bore also a larger sporophyte in addition, and stated further that he had no doubt that several sporophytes might come from a single prothallium.

Among the Lycopodiales and Equisetales the occurrence of two to several embryos per gametophyte has been reported and figured in many instances.

Up to the present time little attention has been devoted to the subject of polyembryony in ferns, and especially to the development of polyembryony experimentally.

This investigation was undertaken for the purpose of determining whether or not polyembryony existed in *Matteuccia Struthiopteris* (L.) Todaro (*Onoclea Struthiopteris* Hoffm.). It was later extended to include *Onoclea sensibilis* L., *Dryopteris mollis* (Jacq.) Hieron., and *Pteris longifolia* L., and the attempt was made to determine to what extent plural embryos could be developed experimentally.

MATERIALS AND METHODS

The spores of *Matteuccia Struthiopteris*, from which the prothallia were grown, were obtained through the courtesy of

Professor Henry F. A. Meier of Syracuse University, Syracuse, New York.* Spores of *Onoclea sensibilis* were collected by the writer in the vicinity of Indiana University, while those of *Dryopteris mollis* and *Pteris longifolia* were secured from plants grown in the departmental greenhouse.

The same methods were used for all the species, excepting the prothallia of *Pteris longifolia*, which were transplanted without being examined under the microscope.

The spores were sown on rich soil from the woods. The soil was sterilized at approximately 100° F. in earthen saucers, in a steam sterilizer, for a period of two to six hours, permitted to cool, and surfaced with a rather thick sowing of spores. The cultures were kept on tables under ventilated bell-jars in the greenhouse, where ordinary greenhouse conditions existed. They were sub-irrigated with distilled water from time to time as needed. The first green of the surface appeared in from five to eight days.

Archegonial prothallia were selected for experimental purposes when they became 3–5 mm. across the lobes. All prothallia were removed from cultures and cleaned sufficiently in distilled water to permit of a good examination. They were then transferred to a drop of distilled water on a slide and carefully examined. If archegonia were open and no spermatozoids present a few male prothallia were placed near the sinus and the whole covered with a cover glass. The sperms were followed to the egg-cells under the microscope. The gametophytes were then left on the slides with cover glass removed, or placed in a ventilated moist chamber for about thirty minutes. On account of class room pressure some of them were permitted to remain in this condition for three or four hours. Results secured in both cases were the same. All archegonial prothallia were then very carefully transplanted about an inch apart on moist soil, care being taken that the specimens were not too wet for twenty-four hours. The soil and air were just moist enough to keep the prothallia in good condition. After periods of from five to twenty-six days the gametophytes were harvested for study.

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* In all probability the spores used were American in origin and would therefore represent *M. nodulosa* (Michx.) Fernald (*Pteretis nodulosa* Nieuwl.), rather than the true *M. Struthiopteris* of Europe (see Fernald, Rhodora **17**: 164. 1915).

Those that were to be used for histological study were fixed in dilute chrom-acetic acid of the following composition, chromic acid 1 gram, glacial acetic 4 cc., water 450 cc., for thirty-six to forty-two hours, and gradually brought into paraffin with chloroform as the solvent. The prothallia were thoroughly cleaned of earth and all foreign matter as soon as they had reached the grade of 50 per cent alcohol in the dehydrating process. At this step to facilitate handling the small prothallia were stained *in toto* in borax carmine. The serial sections, 7–8 µ thick, were stained on the slide with safranin, gentian violet, and orange G, the last stain being dissolved in clove oil.

Also, during these researches a considerable number of prothallia were divided longitudinally through the midrib. Gametophytes bearing embryos were selected from ordinary cultures, cleaned somewhat, and transferred to moistened Bristol board on the stage of a dissecting microscope where, with a very sharp scalpel, a clean cut was carefully made through the cushion. Those which bore no perceptible embryos from observation with a hand-lens were divided on the soil and carefully transplanted to sterilized saucers of soil.

OBSERVATIONS AND RESULTS

In each of almost nine hundred prothallia fecundated and transplanted, one to several spermatozoids were observed to enter and pass down the necks of from two to ten archegonia. That is, sometimes there were but two archegonia open when male plants were placed near the sinus, and again there were a number up to a maximum of ten open at that time.

At the beginning of the work quite a number of prothallia were taken from ordinary cultures, imbedded, sectioned, and examined, for the simple purpose of becoming acquainted with the material, *Matteuccia Struthiopteris*, to be used in the experimentation. During this time two and three eggs were observed on a single gametophyte, each of which bore several sperm nuclei.

Prothallia which were left on the soil for from five to ten days brought the best results. When it was apparent that more than one embryo was present on a prothallium, serial sections were made to determine definitely the facts in the case. On the prothallia of from five to ten days standing it was not always possible to determine the presence or absence of embryos and their number, but after some experience it was not at all difficult to be reasonably sure, so that only those prothallia with two or more embryos were fixed, and after fifteen days it was rarely necessary to section, although it was always done when there was any room for doubt.

The vigorous gametophytes, 3–5 mm. across the lobes at the time of fecundation, gave better results than the older ones, although polyembryony was found among prothallia 6–8 mm. across the lobes. This may be accounted for by the fact that the young prothallia adjusted themselves more readily to the new environment when transplanted than did the older ones, although in each case the same care was used in handling.

In some instances two embryos developed almost equally, and beyond a doubt would have become independent sporophytes; this is well illustrated by PLATE 4, FIGS. 1–3. FIG. 1 is a diagram of a longitudinal section of a prothallium seven days after fecundation, illustrating the location of two embryos of almost equal size about 0.5 mm. apart on the archegonial cushion. Each embryo has approximately seventy-five to one hundred cells, and the meristematic condition of the venters is indicative of all that should be expected in healthful embryos. FIG. 3 (*b*, of FIG. 1) was slightly to one side and a little back of FIG. 2 (*a*, of FIG. 1). The embryo of FIG. 2 may have a few more cells, but it is located slightly nearer the sinus.

FIG. 4 is a diagram of a longitudinal section of a prothallium ten days after fecundation, showing the location of two embryos of very unequal size (*a* and *b*). It is clearly evident that the smaller embryo (*b*) is being starved or at least that some factor is working to its disadvantage. The larger embryo (*a* and FIG. 5), on the contrary, is normal in all respects. If these embryos had been on a more vigorous gametophyte, there is little doubt that they would have become independent in their existence, but such is not to be expected from the common run of prothallia, especially when one embryo is considerably nearer the sinus.

To determine what would result from a fecundated egg in a prothallium which had an embryo already started at the time of selective fecundation, several very vigorous prothallia were selected each of which bore an embryo about twenty-five days old. Several archegonia were open in each instance. After eight days the harvesting was done, and TEXT FIG. 1 illustrates one of the results obtained. The smaller embryos were all in very good condition but doubtless would have soon succumbed. It is especially interesting to note that *a*, *b*, and *c* were closer to the sinus than was the dominate sporophyte. This difference in position probably largely accounts for the existence of the smaller embryos.

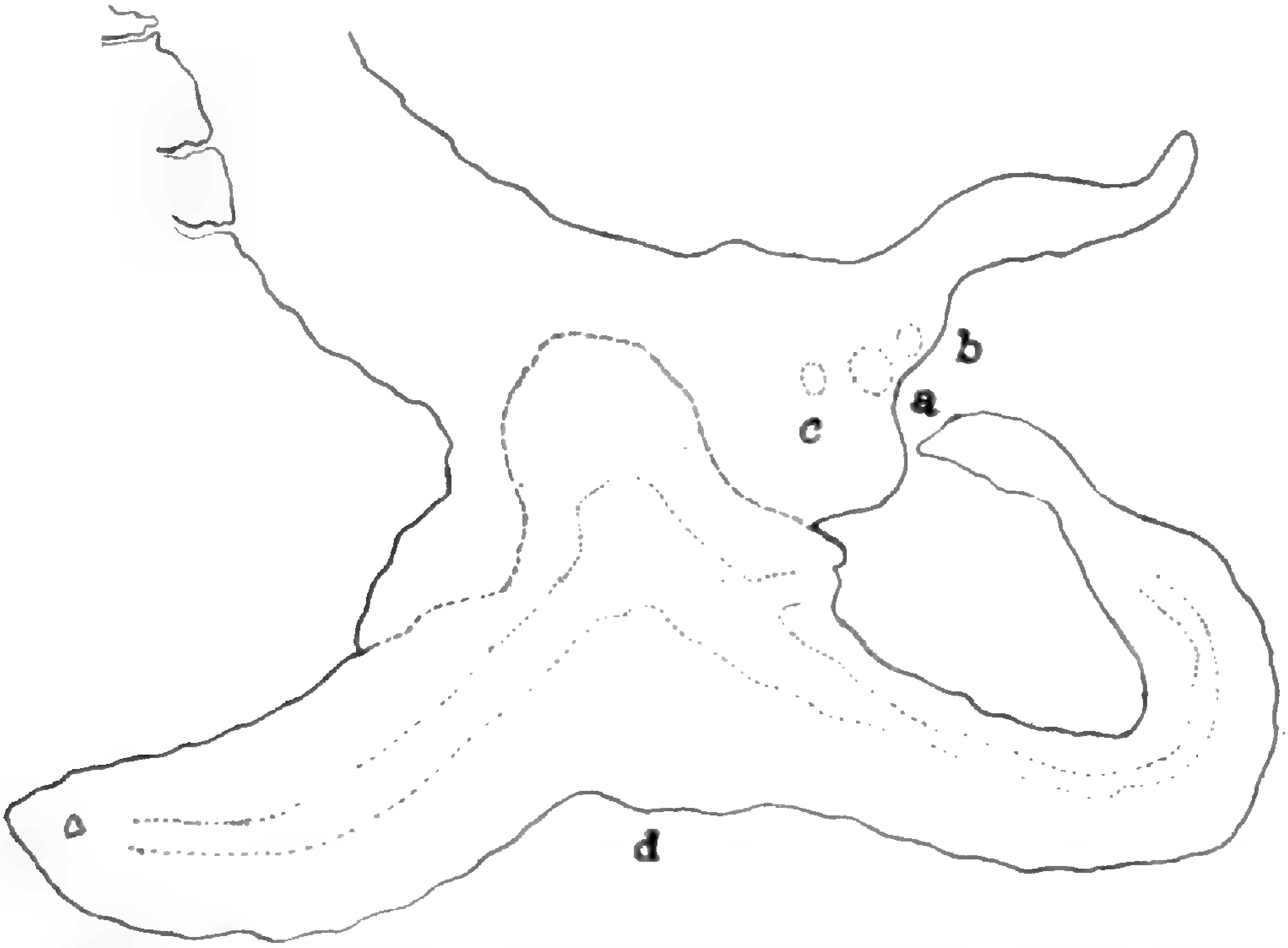
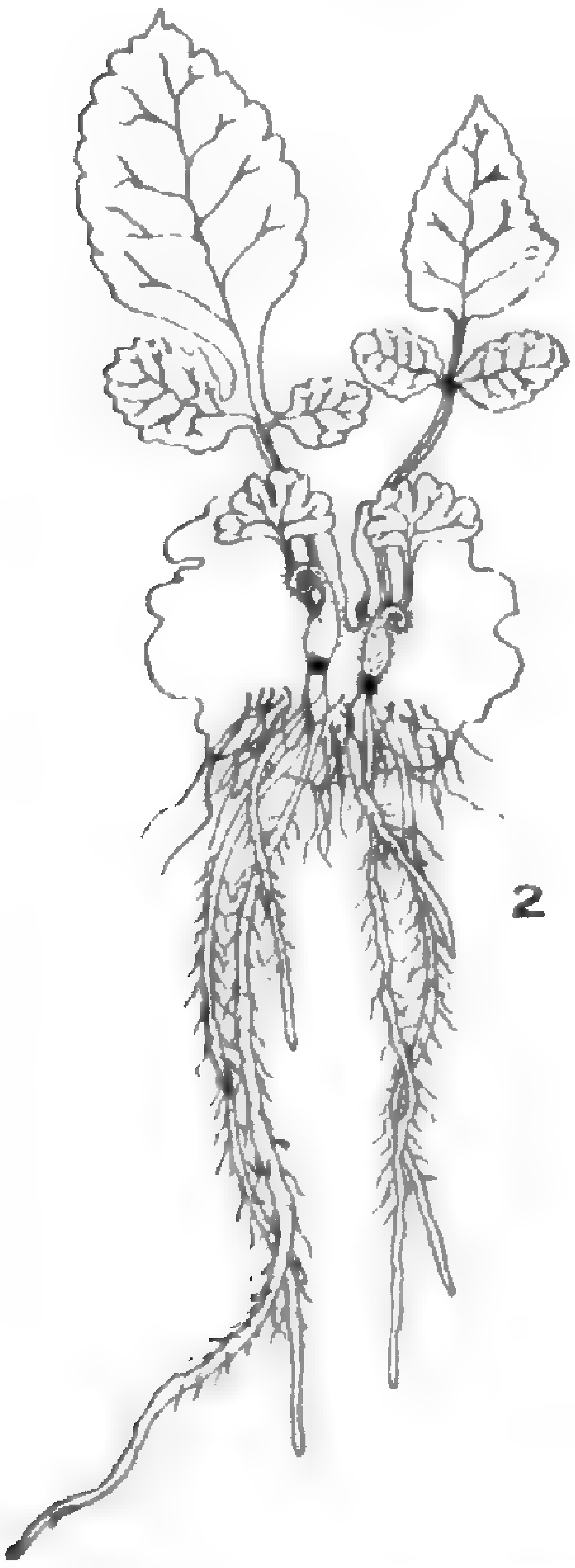
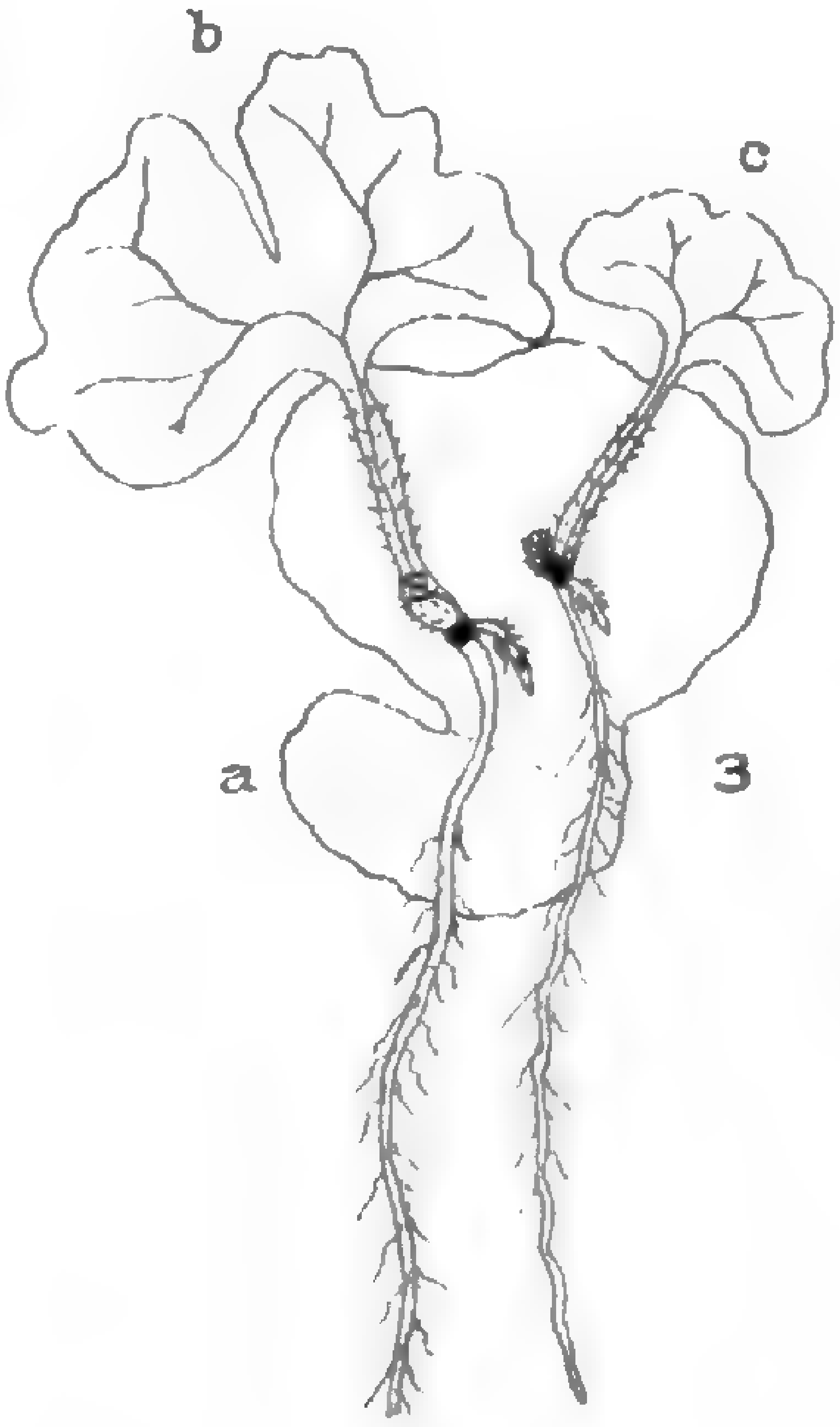


FIG. 1. Three embryos and a young sporophyte on a single prothallium of *Matteuccia Struthiopteris*. *a*, embryo probably in octant stage; *b*, embryo two-celled; *c*, embryo two-celled; *d*, young sporophyte about thirty-two days old.

TEXT FIG. 2 is from a gametophyte of *Pteris longifolia* with two independent sporophytes. These were fine vigorous individuals, well back from the sinus, and distinctly separated on the two sides of the archegonial cushion. *Pteris longifolia* lends itself very well to experimentation; it is a vigorous grower, and it is not at all surprising that it may bear plural embryos under natural conditions.

To determine just what would happen if a prothallium bearing two embryos were halved, several such gametophytes were selected from ordinary cultures and carefully divided by the method stated in the foregoing. In three instances both embryos were left on one lobe. In each case the embryos came to independent existence and grew well. Ten prothallia were divided so that there was one embryo on each half. Six of the ten cases in this experiment developed and came to independent existence. This demonstrates the fact that a portion of a prothallium is capable, when isolated, of supporting a young sporophyte.





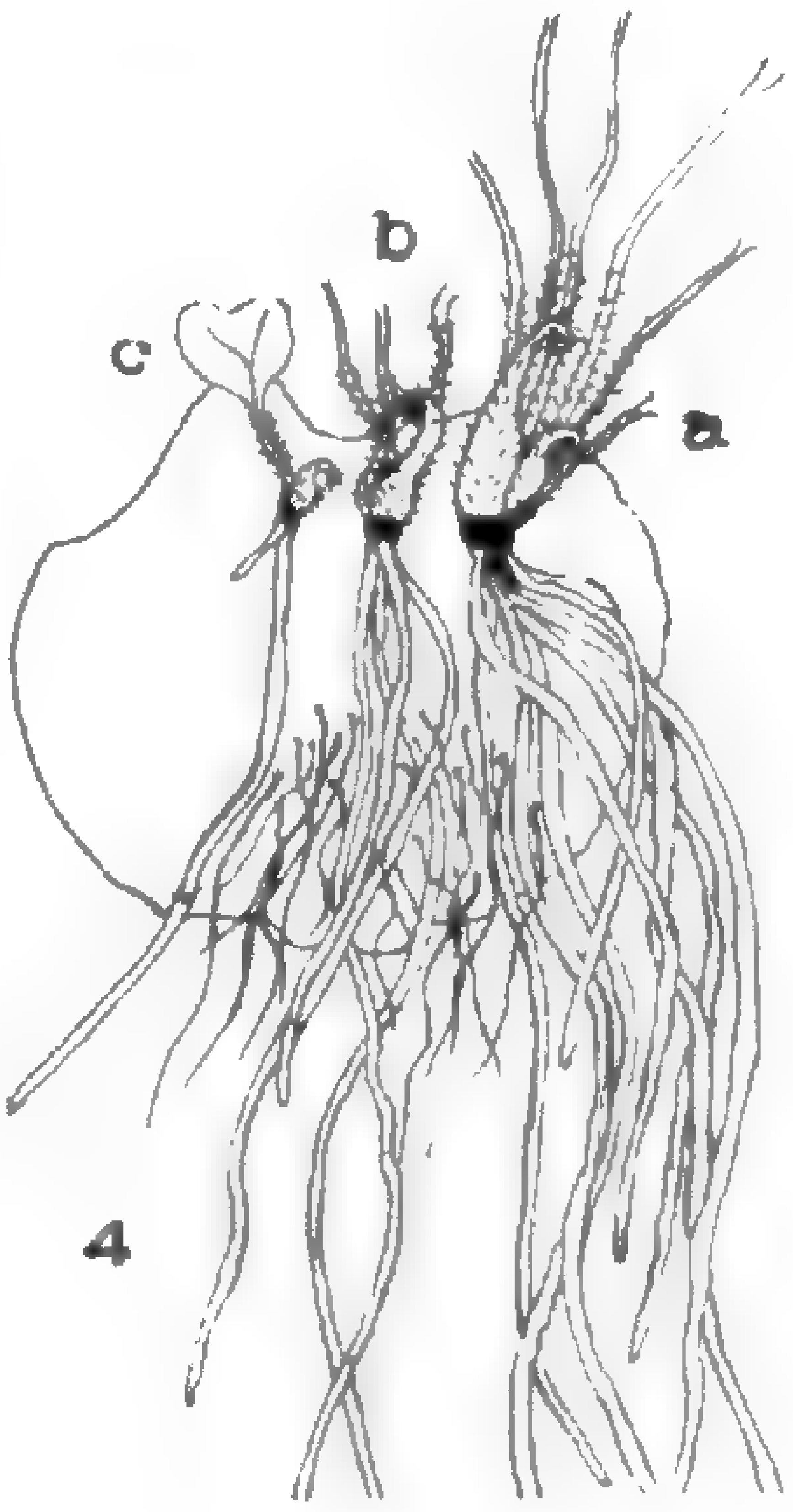


FIG. 2. Two sporophytes on a single gametophyte of *Pteris longifolia* (as seen from the ventral view), located on opposite sides of the archegonial cushion and well back from the sinus.

FIG. 3. Regenerated lobe of a prothallium of *Dryopteris mollis*, bearing two normal, thrifty, young sporophytes, *b* and *c*, widely separated on the archegonial cushion. *a*, the old half of the original prothallium.

FIG. 4. Three sporophytes on a regenerated lobe of *Matteuccia Struthiopteris*. They came in the order as lettered.

Two hundred seven prothallia, 3–5 mm. across the lobes, of the various species, which bore no embryos, were then divided longitudinally through the apical sinus. Apparently very little inconvenience was suffered by these severed parts. They recovered readily and less than 2 per cent of the prothallia were lost. In every instance the severed halves either developed an embryo-sporophyte within six to ten days or regeneration began. The regenerated part was always more vigorous than the part from which it came. In as much as the regenerated parts always became monoecious, water was added from time to time to the individual prothallia, and there were permitted to dry somewhat each time before watering, in order to insure fecundation.

TEXT FIG. 3 shows two independent sporophytes which developed on the archegonial cushion of a regenerated lobe. The old lobe is shown at *a*. It is interesting to note that the regenerated lobe is larger and much more vigorous than the older one. The new lobe did not produce an apical sinus in this instance, although a well-formed archegonial cushion occupied a considerable portion of its extent.

The fact that at least three sporophytes may be induced to develop to independent existence from a single lobe is well illustrated in TEXT FIG. 4. The original lobe, from which the new one came, was absorbed, and this very vigorous new lobe grew to a width of 10 mm. without forming a sinus, before a sporophyte, *a*, appeared, fifty-four days after the dividing of the original gametophyte. Twenty-six days later another sporophyte, *b*, came near the first. After a lapse of twenty-nine days more a third sporophyte, *c*, came. The first and the second sporophytes grew as well as one should expect, while the third grew very slowly but otherwise normally. All three of them would doubtless have become independent sporophytes.

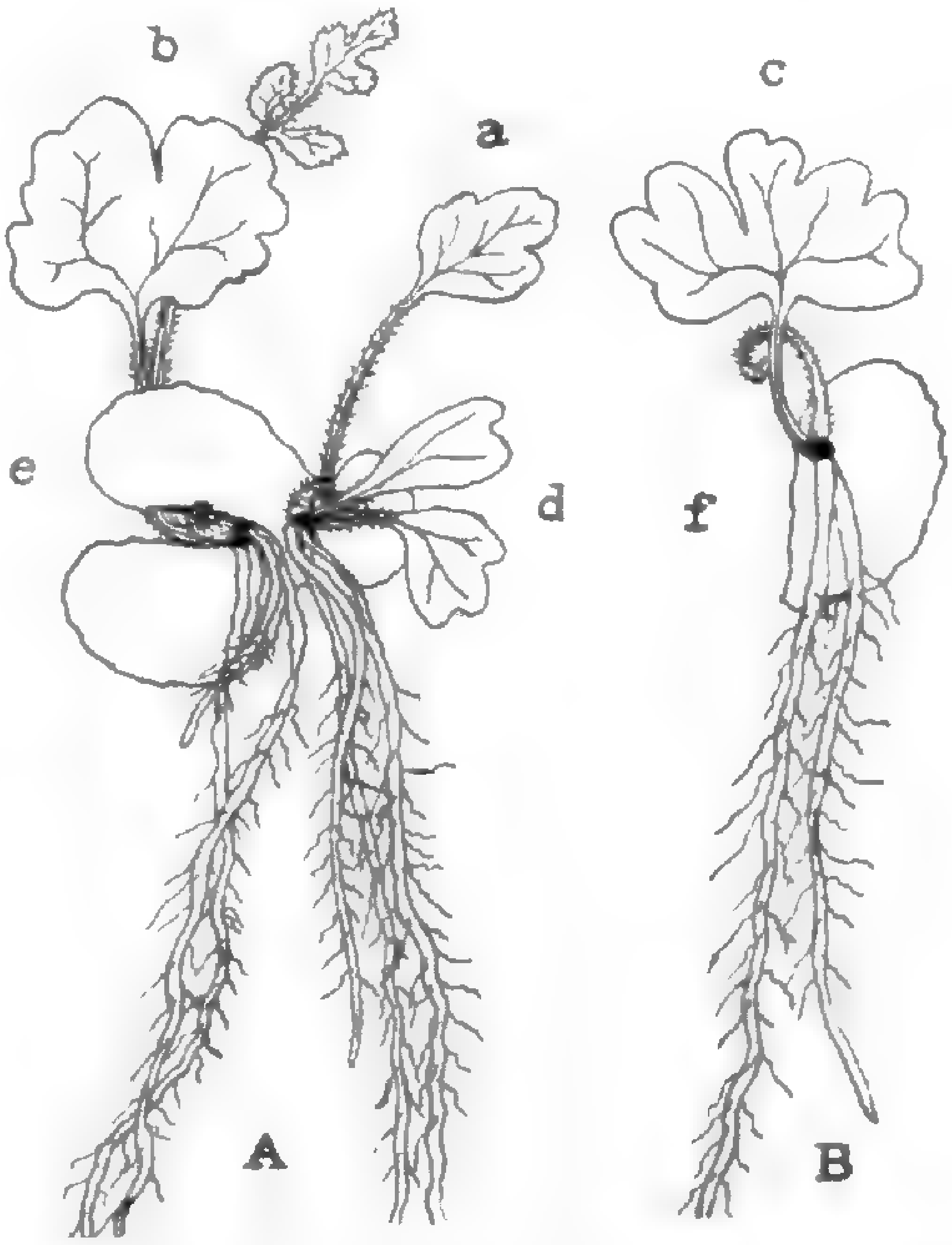
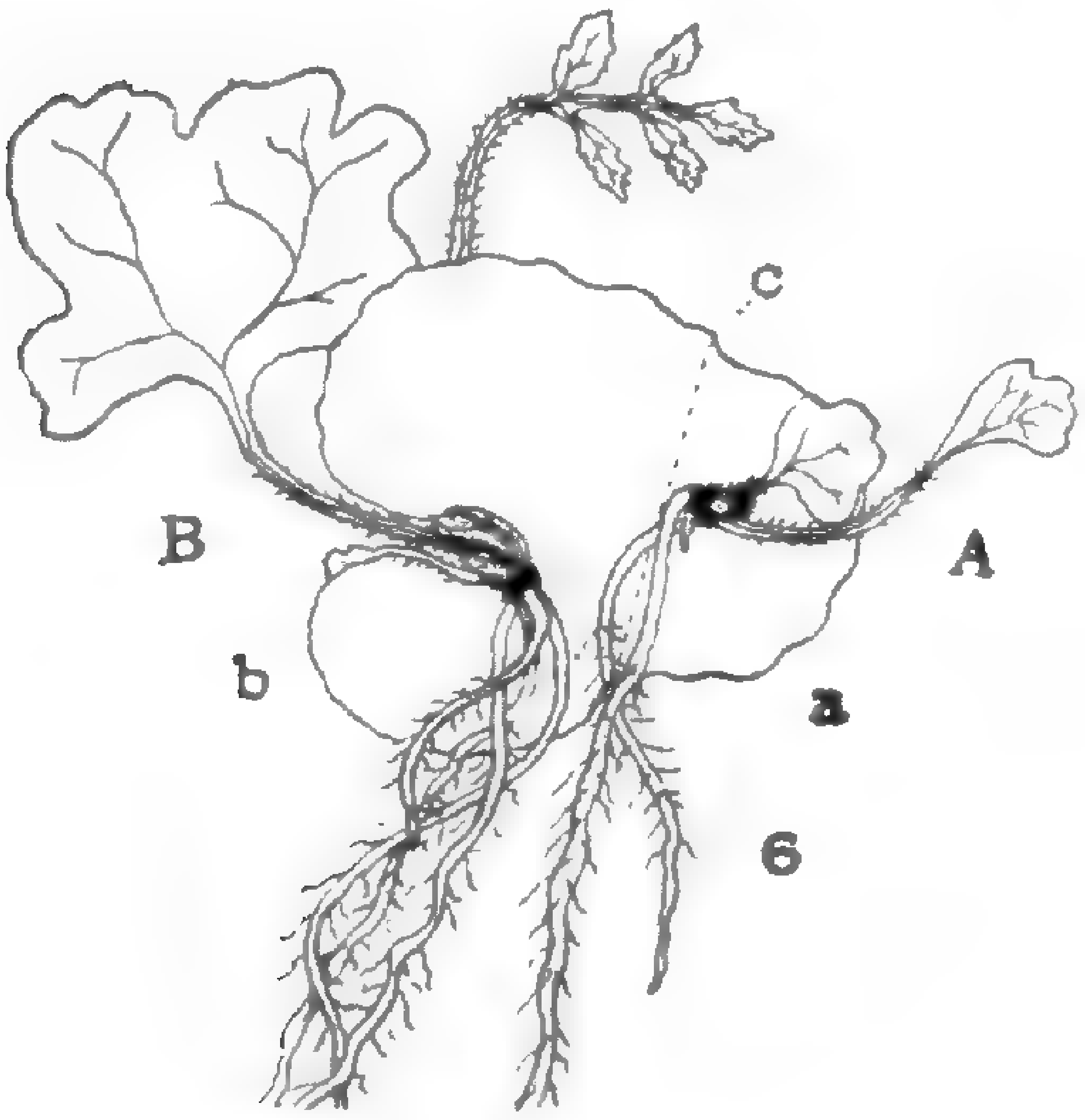


FIG. 5. A typical result obtained by dividing a gametophyte of *Matteuccia Struthiopteris* into longitudinal halves. *A*, two sporophytes on one regenerated prothallium, *e*; *a*, the older sporophyte; *b*, the younger sporophyte; *d*, the old half of the original prothallium. *B*, the other half, *f*, of the original prothallium upon which a sporophyte, *c*, soon began to develop.

Regeneration usually produced a new normal heart-shaped gametophyte on which two sporophytes commonly developed, as is illustrated by TEXT FIG. 5, *A*. The larger sporophyte, *b*, was seen later than the smaller one, *a*. It is interesting to note here that the smaller one, although older, was not doing as well as the younger one, which was located nearer the apical sinus of the regenerated part. That more nutritious food is available there seems reasonable. TEXT FIG. 5, *B*, *c*, is a sporophyte which developed on the other original lobe near the region of the apical sinus, no regenerated part having been formed.



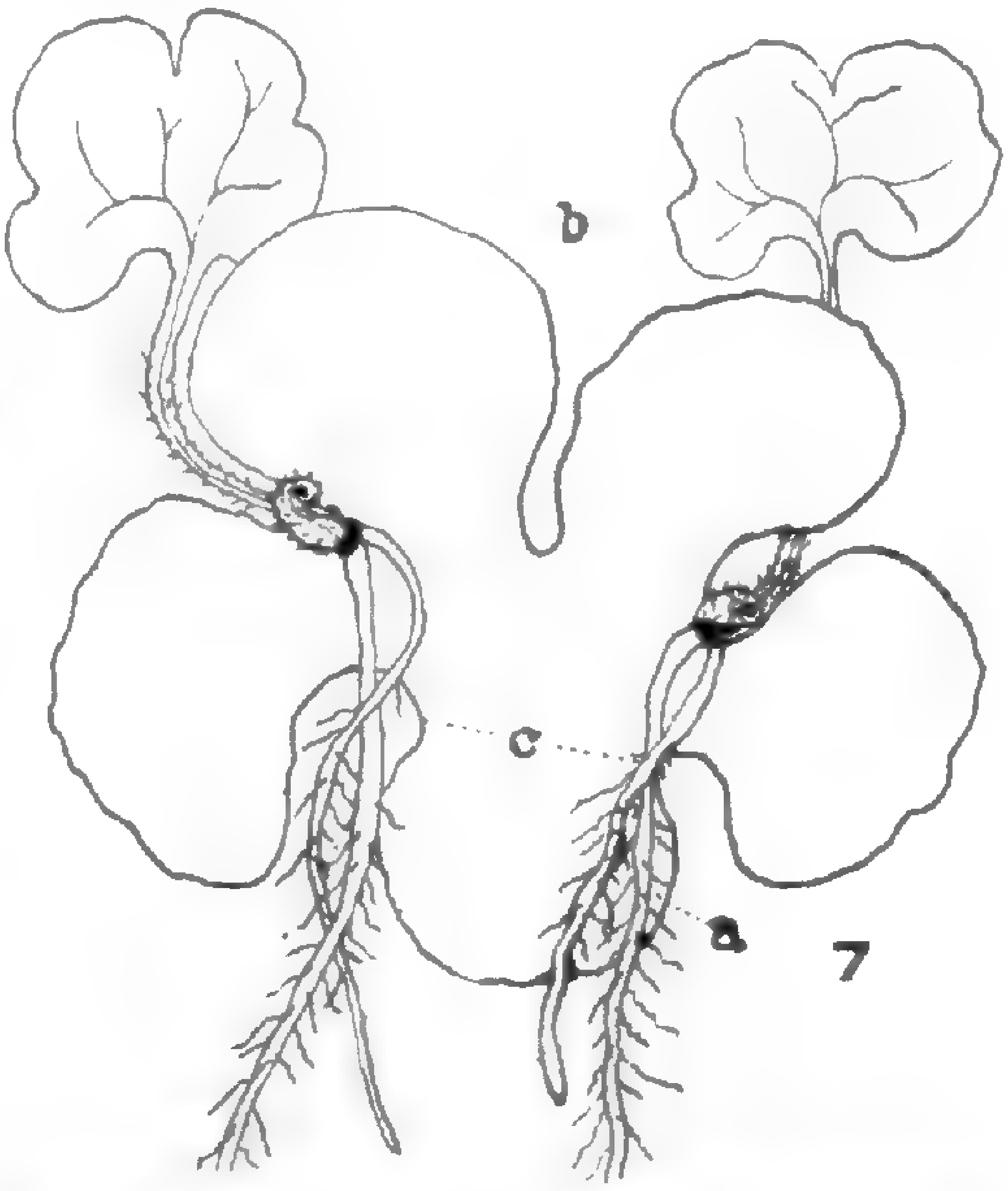


FIG. 6. Gametophyte of *Dryopteris mollis* bearing two sporophytes. *A*, older sporophyte on the old half of the original gametophyte, *a*; *c*, in approximately the boundary line between *A* and *B*. *B*, the regenerated gametophyte, *b*, bearing the younger but more thrifty sporophyte.

FIG. 7. Two sporophytes on regenerated prothallium of *Matteuccia Struthiopteris; a*, old half of original prothallium; *c*, approximate boundary line between the old and new parts; *b* the regenerated prothallium.

It was not uncommon to find that, after a regenerated part had attained a width of 7–8 mm. across the lobes, a sporophyte came from the old original part ahead of one on the regenerated part. From all appearances the entire prothallium, including old and new parts, was morphologically one with the old midrib branched. This phenomenon is illustrated in TEXT FIG. 6. The smaller but older sporophyte, *A*, came well back on the broadened cushion, six days previous to the appearance of the larger one, *B*, which, however, soon outstripped the older in development. The whole was transplanted, and four months later, at the time of this writing, both sporophytes are still growing but *B* is far in advance of *A*.

TEXT FIG. 7 shows two widely separated embryos of *Mattenccia Struthiopteris*, each one near a sinus of a regenerated part, both of which came from one half of the previously divided prothallium. Both sporophytes appeared about the same time and developed slowly, although about equally, as illustrated. This sort of occurrence was not as common as that in which only one part was regenerated, yet several instances like this were observed. At this time it is impossible to say just what the nature of the development of the archegonial cushion is, but we are inclined to the notion that the original cushion has simply branched, and that therefore both sporophytes are located on one cushion instead of on two independent and remote archegonial cushions. The condition illustrated by TEXT FIG. 7 was more common among gametophytes of *Dryopteris mollis* than among any other species studied.

A few prothallia were quartered by dividing the prothallium longitudinally and then at right angles to the first cut through the archegonial cushion. In one instance one quarter started a sporophyte within a few days. Two of the remaining quarters regenerated new normal prothallia, each of which brought a sporophyte, and one of these also produced a sporophyte on the older part. The remaining quarter produced two new prothallia which in turn developed two sporophytes. In another instance two of the quarters regenerated new normal prothallia from which sporophytes came; the remaining two proliferated quite a number of prothallium-like forms, from which no sporophytes had developed at the time of this writing.

SUMMARY

Polyembryony in *Matteuccia Struthiopteris*, *Onoclea sensibilis*, *Dryopteris mollis*, and *Pteris longifolia* may occur, though not frequently, in ordinary cultures and perhaps in nature.

Under experimental conditions two to several embryos may be made to develop on a gametophyte of the above named species.

In prothallia that have been divided longitudinally, each half may be made to grow and to develop two or more embryos.

In some cases each half may regenerate one or two heart-shaped lobes on which an embryo or embryos may be produced, as well as on the original half.

Parts of quartered prothallia under favorable conditions may continue growth and develop sporophytes.

When the gametophyte of a polypodiaceous fern is of sufficient vigor one to several or many normal embryos or sporophytes may be nourished and brought to independent existence.

This investigation was done under the direction of Professor D. M. Mottier, at Indiana University, and I wish to express my thanks to him for his invaluable aid in the work and for the helpful criticisms given during its course.

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LITERATURE CITED

Atkinson, G. F. ('93). Two perfectly developed embryos on a single prothallium of *Adiantum cuneatum*. Bull. Torrey Club **20**: 407, 408.

Bruchmann, H. ('06). Ueber das Prothallium und die Sporenpflanze von *Botrychium Lunaria* Sw. Flora **96**: 203–230. *pl. 1, 2.*

Buchholz, J. T. ('22). Developmental selection in vascular plants. Bot. Gaz. **73**: 249–286. *f. 1–28.*

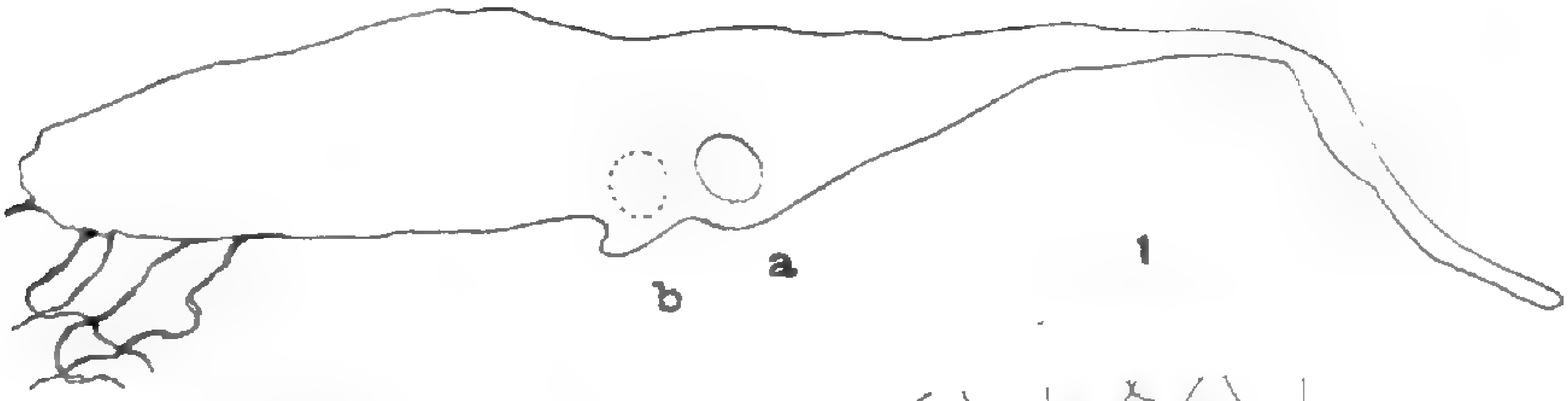
Campbell, D. H. ('92). On the prothallium and embryo of *Osmunda Claytoniana* L. and *O. cinnamomea* L. Ann. Bot. **6**: 49–94. *pl. 3–6.*

—— ('21). The gametophyte and embryo of *Botrychium obliquum*, Muhl. Ann Bot. **35**: 141–158. *pl. 8 + f. 1–11.*

Czaja, A. T. ('21). Ueber Befruchtung, Bastardierung und Geschlechtertrennung bei Prothallien homosporer Farne. Zeitschr. für Bot. **13**: 545–589. 1921.

Farmer J. B. ('92). On the embryogeny of *Angiopteris evecta*. Ann. Bot. **6**: 265–270. *pl. 15.*

Goebel, K. ('87). Morphologische und biologische Studien. II. Zur Keimungsgeschichte einiger Farne. Ann. Jard. Bot. Buitenzorg **7**: 74–119. *pl. 10–13.*



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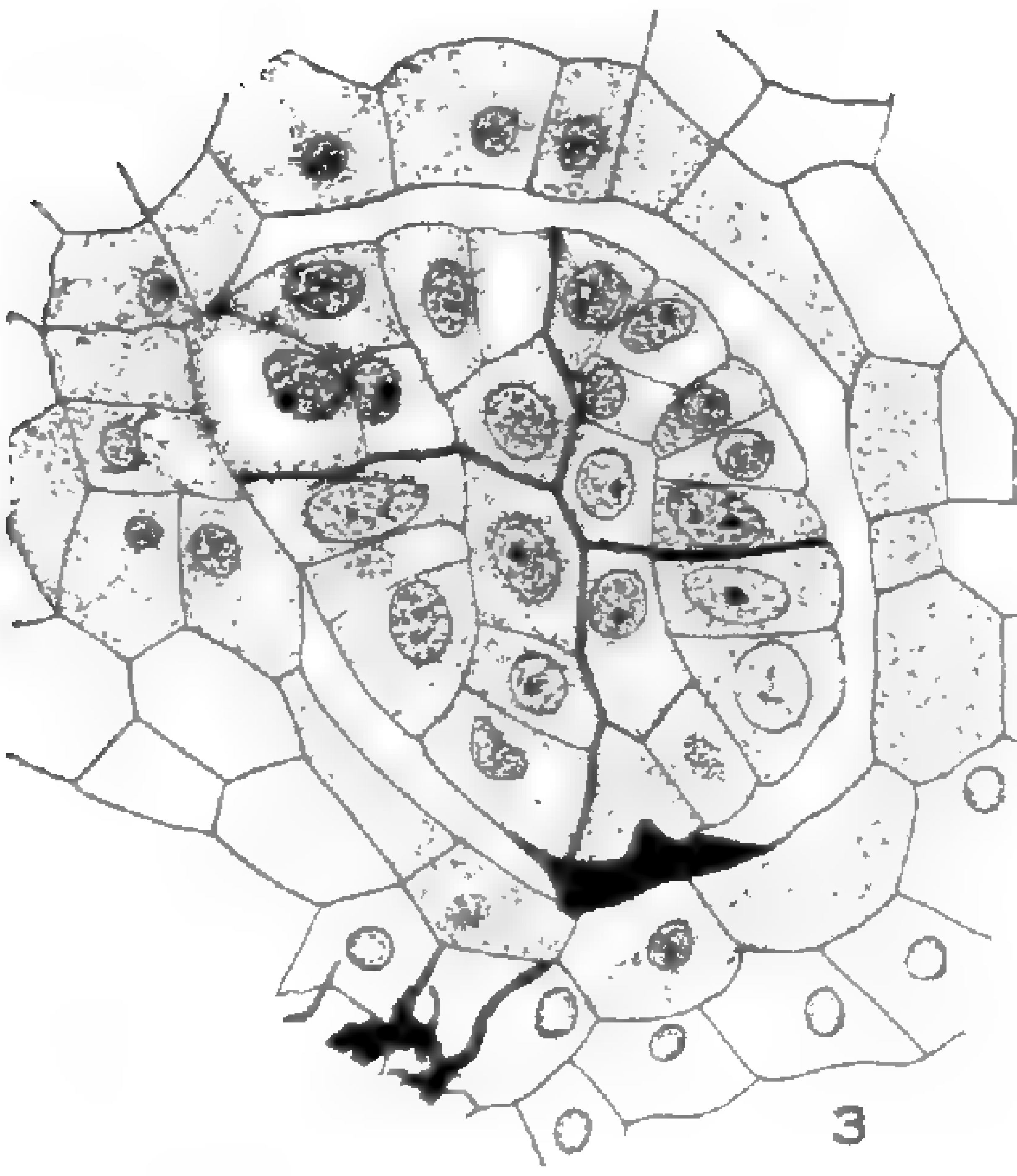

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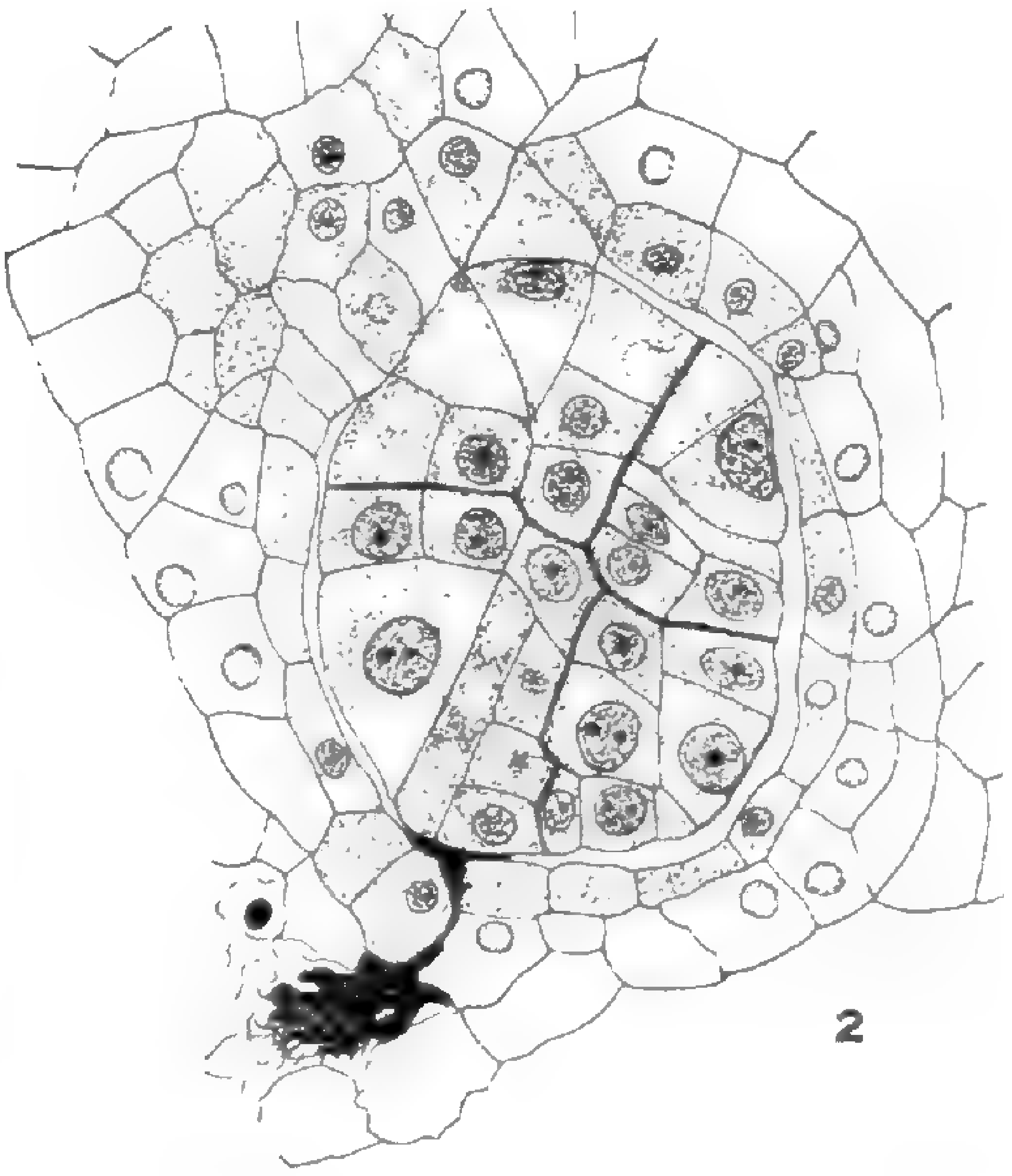

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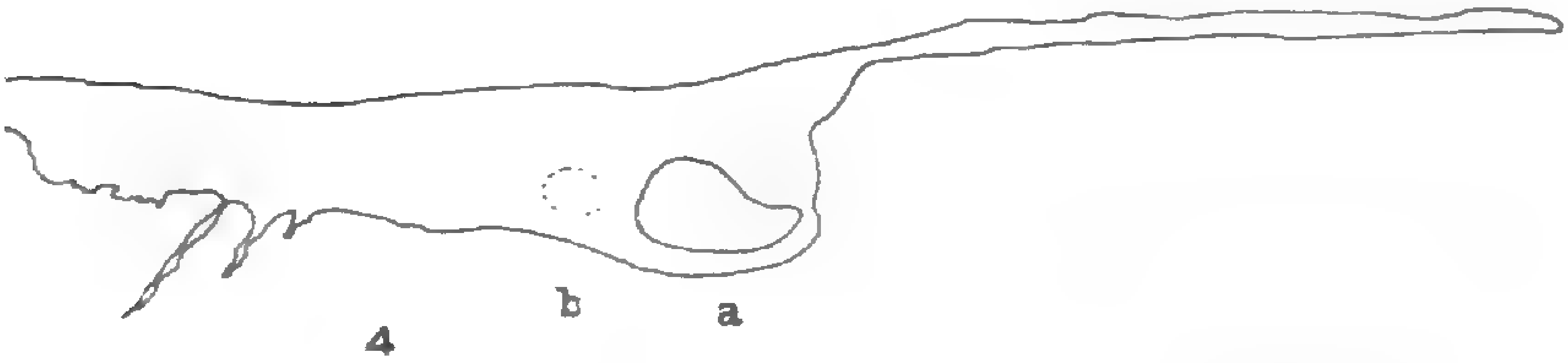

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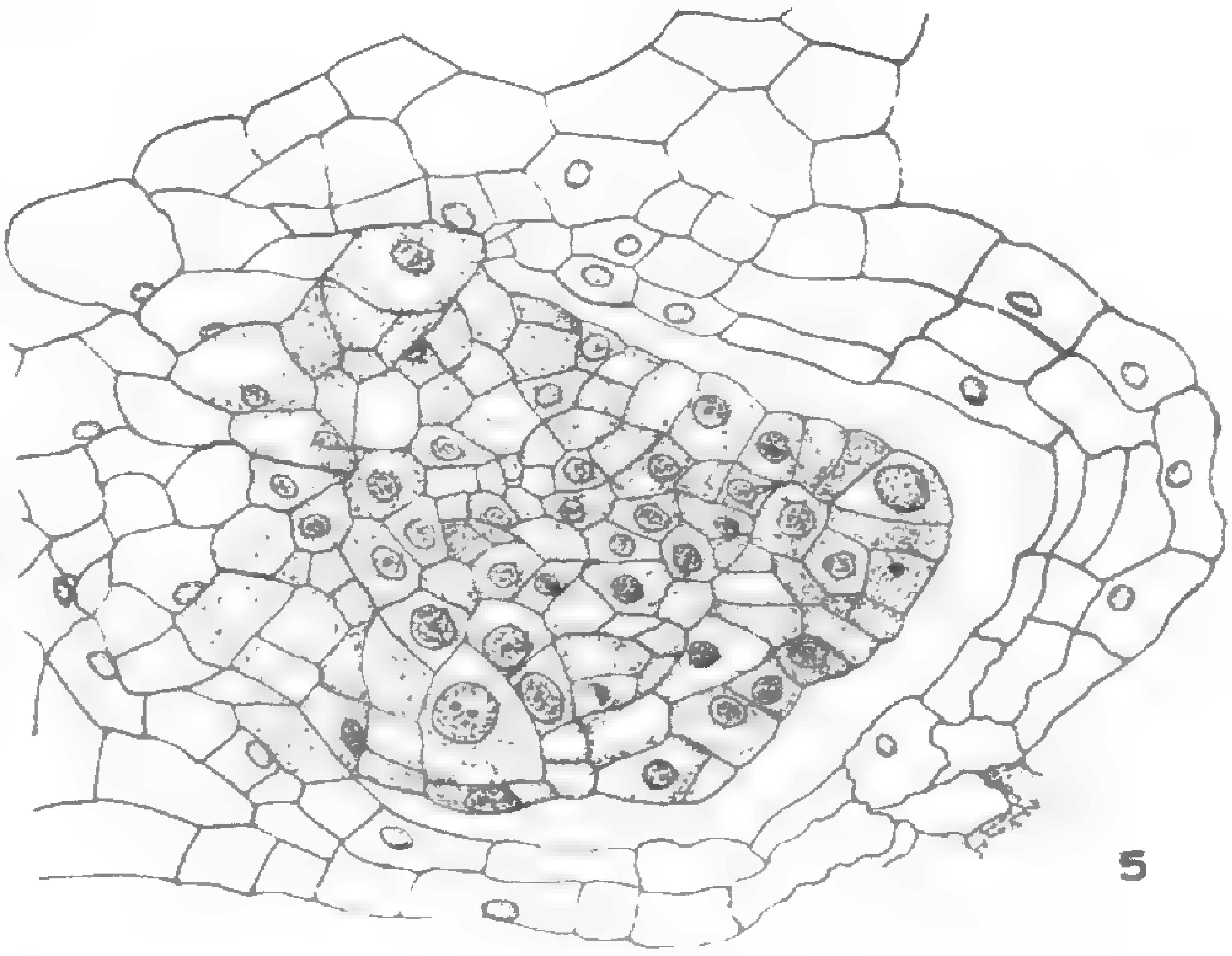

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ETTER: POLYEMBRYONY IN FERNS

Explanation of plate 4

POLYEMBRYONY IN MATTEUCCIA STRUTHIOPTERIS

FIG. 1. Outline of longitudinal section of a prothallium, showing position of two small embryos, *a* and *b*.

FIG. 2. Longitudinal vertical section of embryo *a* of FIG. 1, with surrounding cells of prothallium.

FIG. 3. The same of *b*, FIG. 1.

FIG. 4. Outline of longitudinal section of prothallium showing position of the two embryos *a* and *b*; *a* is much larger than *b*.

FIG. 5. Longitudinal vertical section of embryo *a* of FIG. 4, with surrounding cells of the prothallium.

FIG. 6. Same of embryo *b* of FIG. 4. This smaller embryo was abnormal and probably would not have developed into an independent sporophyte.

The genus Heliocarpus

E. E. WATSON

The latest literature, treating of the genus *Heliocarpus*, consists of two articles by Rose* and a review of the first of these by E. G. Baker.† A perusal of these articles and the examination of a large number of specimens of the genus in the herbarium of the New York Botanical Garden, in the herbaria of Columbia and Harvard Universities, and in the United States National Herbarium, all of which institutions very kindly loaned their specimens, suggested the desirability of a general review of the genus at this time.

The genus was established by Linnaeus in 1737 in the Hortus Cliffortianus. Here appeared his description of a new genus and species, which he called *Heliocarpos americana* ‡ together with a drawing of a portion of the plant. In the Species Plantarum, 1753, Linnaeus merely refers the reader to the description of *Heliocarpos americana* in the Hortus Cliffortianus. It is to be noted that Linnaeus preserved no specimen in his herbarium. There are, however, specimens labeled *H. americana* in the Banksian and Sloane Herbaria.

In 1821 the description of *H. popayanensis* H. B. K. appeared. This description is quite full and the differences between the new species and *H. americana* are clearly pointed out. This

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* A synopsis of the species of *Heliocarpus*. Contr. U. S. Nat. Herb. **5**: 125–129. *pl. 7–10.* 1897.

Notes on *Heliocarpus*, with new species. Ibid. **8**: 315–317. 1905.

† Two old American types. II.—*Heliocarpus americana* L. Jour. Bot. **36**: 130 132. 1898.

‡ The correct gender of the noun *Heliocarpus* has been in much dispute. In general, Latin or latinized names of plants and especially of trees are feminine, but the rule has numerous grammatically acknowledged exceptions. Classical Latin authors are by no means unanimous, and not always consistent, the same plant name being treated sometimes as masculine and sometimes as feminine by the same author. Linnaeus considered the noun feminine, so do Baker and Rose. Most other botanists, however, who have used the noun *Heliocarpus* have considered it masculine; and most other plant names ending in *-carpus*, are usually treated as masculine. If we are to consider *Heliocarpus* feminine, consistency would demand the same gender for all such plant names. It would seem unwise, therfore, to oppose the momentum of long-established usage in an unimportant detail.

was followed in 1857 by Seemann's publication of *H. arborescens*, which does not belong in this genus. In 1858, Turczaninow added three species, *H. tomentosus*, *H. appendiculatus* and *H. trichopodus*, and, five years later, *H. oblongifolius*.

In 1886, Schumann, unable to accept the seven described species, reduced them all to *H. americanus* with the two varieties *typicus* and *popayanensis*. His argument is based upon the existence of intermediate types. It is quite evident from his article that he had a very limited amount of material and that his examination was not very minute, for most of these species are distinct even to a casual observer.

Schumann cites for *H. americanus* var. *typicus: Regnell III. 285* from Brazil, *Mosen 3825*, *Riedel 424*, *Balansa 2295*. Of these I have seen only *Regnell III. 285*, which does not resemble *H. americanus* in the least. Schumann does not mention separate types for his two varieties, and the specimens cited include, as might be expected, widely varying plants.

In the same year, Sereno Watson published descriptions of three new species, *H. Palmeri*, *H. polyandrus*, and *H. attenuatus*, all clearly distinct. Eleven years later, Robinson added *H. glanduliferus*, characterized by red glands on the stem and excessive glandulosity of the lower serrations of the leaves. At about the same time, Rose published, in the first of the papers already noted, a synopsis of the genus in which he enumerated fifteen species, including several of his own. The following year E. G. Baker published his brief review of Rose's synopsis, offering some remarks on the earlier species, and endeavoring to establish the identity of *H. americanus*.

It may be well, at this point, to interrupt our chronology to discuss this type of the species. The situation is peculiar. It must be remembered that Linnaeus preserved no specimen of the plant he described, and his description is only fairly complete. The drawing represents a plant with stipules and without either fruits or flowers. As stipules in this genus are early deciduous, and as the drawing presents neither fruit nor flower, we conclude that the drawing is from an immature plant. On the same plate, however, is a drawing of a single fruit, which, so Linnaeus informs us, was sent to him by Miller, presumably from the Chelsea Garden. It is not explicitly stated that the two drawings were made from parts of the same plant. Nor does it appear from Linnaeus' writings just what was the source of the plant in the Clifford Garden at Chelsea. The matter is made still more obscure by the fact that we have only one or two plants in the various herbaria that even remotely resemble Linnaeus' drawing or fit into his description. Baker discusses at some length the probable identity of the specimens in the Banksian and Sloane Herbaria, labeled *H. americana*, and concludes, no doubt correctly, that they are the same as *H. tomentosus*, and accordingly reduces the latter to synonymy, ignoring the fact that these Banksian and Sloane specimens in no wise agree with Linnaeus' drawing or description. His assumption that these specimens represent the same plant that Linnaeus had in mind does not follow at all, and is, indeed, in view of the evidence, most improbable. What the Banksian and Sloane specimens may be has nothing whatever to do with the question at issue—the identity of Linnaeus' plant. Since Linnaeus preserved no specimen, the only criteria we have are his drawing and description; and, as already stated, these do not agree with the Banksian and Sloane specimens at all. We are, however, indeed fortunate in possessing a specimen which does agree in all essential particulars with the drawing and description, and that specimen is *Fendler 1277 B*, from Venezuela, in the Gray Herbarium. This plant has lobed leaves, and these, together with the stems and petioles, are "fere glabra," as Linnaeus says. It is true that Linnaeus does not mention the long appressed hairs on the upper surface of the leaves, but except in this single particular the whole plant answers very satisfactorily to all the specifications.

Baker emphasizes also the probability that the plant in Clifford's garden came from Vera Cruz, and that it was *H. tomentosus*, the most abundant species in that vicinity, but it is far from proved. It is simply impossible that Linnaeus could have failed to notice the dense tomentum of the lower surface of the leaves, almost as dense as in *Verbascum Thapsus*. Nor would he have described such a plant as "fere glabra,' nor ascribed lobed leaves to *H. tomentosus*. If we are not certain as to what *H. americanus* is, although I think we may be reasonably sure, we are absolutely certain that it is not *H. tomentosus*. I have not seen any plant from the vicinity of Vera Cruz like *Fendler 1277 B*, but that does not prove that it does not grow there; and since we do not know the source of Linnaeus' plant more clearly than that it came from the warmer parts of America, it is not at all impossible that it came from Venezuela. Accordingly, I consider *Fendler 1277 B*, from Venezuela, the true *H. americanus*, the type of the genus, and I cannot concur in Baker's reduction of *H. tomentosus* to synonymy.

Baker also adds a variety of *H. popayanensis* which he calls *Purdiei*, stating that in this variety "the leaves are much more densely tomentose," but without mentioning a type. The degree of pubescence varies greatly in this genus, and it does not seem to me that such a variable character as degree of pubescence is sufficient to establish the separate identity of even a variety, especially with no type cited. I suppose if there had been other differences they would have been mentioned.

In 1901, J. Donnell Smith published Rose's description of *H. Donnellsmithii*, and in 1905 appeared the second paper by Rose, in which he described *H. laevis*, *H. microcarpus*, and *H. velutinus*. I am unable to separate Rose's *H. microcarpus* from his *H. reticulatus*, published in his first synopsis. Both have tuberculate-appendaged sepals and a short style, and the reticulations of the leaves vary throughout the two groups. There seems at first sight to be a difference in the fruits, but such difference as there is is one of degree. Both are sessile and orbicular, and the faces of both are provided with plumose hairs, but the fruit of the group called *microcarpus* is smaller. On one of Pringle's specimens, No. 9693, are two inflorescences, presumably, error eliminated, from the same plant. If these are from the same plant, it is impossible to separate the two groups. The fruit in this genus remains a long time on the tree, and it is more than probable that the weather might have a marked effect upon such fragile structures as exposed, plumose hairs. I have, therefore, united *H. microcarpus* and *H. reticulatus* under the latter name.

In April, 1904, Brandegee described *H. glaber* from Sinaloa, and in 1905, as already noted, Rose published *H. laevis* from Batanos in the state of Jalisco. In the Gray Herbarium are two specimens from Sinaloa labeled *H. glaber*, one marked "Type" from Cerro Colorado, and the other from the vicinity of Culiacon. There is no town in Sinaloa named Cerro Colorado, but I assume this to be a local name and take it that both plants are from Sinaloa, near Culiacan, as stated on the label. Brandegee describes his plant as "leaves glabrous" and his type is so, but the other is by no means glabrous, though otherwise the two specimens are identical. I have carefully compared Rose's *H. laevis* with Brandegee's *H. glaber* and, except for slightly varying degrees of pubescence, I am unable to separate them. Moreover, these two groups do not differ in any important character from *H. polyandrus*. The fruit in all three is characteristic and similar, having a narrow fringe and a shallow longitudinal groove on the faces. After careful consideration, I have come to believe that the three groups are one species, and have united them under the name *H. polyandrus* S. Watson.

I am unable to accept Loesener's *H. Caeciliae*, published in 1913. The type is *Seler 4976*, which I have not seen. Loesener's description is very complete except for the flowers. He admits its near relationship to *H. Donnellsmithii* and points out the difference to be, "der [*H. Donnellsmithii*] durch breitere mehr dreieckig kreisförmige Blattspreiten und lockerere Blütenstände von *H. Caeciliae* abweicht." Nothing in his description would prevent his plant from being classified as *H. Donnellsmithii*, and the differences he mentions are well within the limits of fluctuating variation. He mentions, indeed, the densely hirsute faces of the fruit, but says, "videtur nondum plane matura." *Kellerman 6068*, from Guatemala, answers to this description perfectly but is plainly *H. Donnellsmithii*. Rose, describing the latter species, says the densely hirsute faces of the fruit become rugose and glabrate with age.

Hochreutiner, in 1914, published six new species: *H. diclinus* *H. boliviensis*, *H. glabrescens*, *H. Rosei*, *H. stipulatus*, and *H. tigrinus*. The latter proves not to belong to the genus, and I have strong suspicions about *H. stipulatus*. He describes also a variety of *H. popayanensis*, which he calls *grandifolius*, the difference being that in the variety the leaves are larger and usually not lobed, while the panicle is smaller. There is such variation in these characters throughout the whole group that I am unable to accept the variety and have reduced it to synonymy. Also, Hochreutiner's *H. glabrescens* proves to be identical with Robinson's *H. glanduliferus* and is accordingly united with it. The only difference between these two species is in the degree of pubescence of the leaves which, as I have already pointed out, is very variable. The fruit and flowers are practically identical. Hochreutiner also points out that *H. Nelsoni* Rose is the same as a plant that was originally incorrectly placed in the genus *Grewia* under the specific name of *terebinthinaceus*. To quote Hochreutiner, "nous avons á l'Herb. Delessert un original du jardin de Montpellier, déterminé par de Candolle et en outre, le no. 1064 de Berlandier, cité par Rose sur l'apui de son *H. Nelsoni*, et ces deux plantes sont identiques." Hochreutiner's conclusion seems tenable.

I have not seen the type of *H. stipulatus*, *Poeppig 3102*, nor any plant of the genus that answers to his description. *Botteri 1110*, Gray Herbarium, does, indeed, fulfil the requirements of the description, but, unfortunately, does not belong to the genus. The inflorescence is, as Hochreutiner says in his description, "divaricata, ramosa plus minus corymbiformis," which is not characteristic of this genus, and the structure of the flower is less so.

Concerning the characters of the genus *Heliocarpus*, it is to be noted that the knowledge acquired by the examination of a large amount of material renders inadequate the diagnoses of Engler and Prantl and of Bentham and Hooker. In *Triumfetta*, a closely allied genus, the apex of the receptacle, above the sepals and petals, is crowned by a saucer-shaped structure with ciliate rim in which repose the ovary and stamens. This structure is not found in any of the undisputed species of *Heliocarpus* but is present in all the species of *Triumfetta* that I have examined. Also, in *Triumfetta*, the sepals are usually, if not always, long-appendaged, while in *Heliocarpus*, the appendages, if any, are short. In *Triumfetta*, the style is usually long and more or less capitate, while in *Heliocarpus* it is invariably bifid with spreading lobes. *Seemann 96* and *Pittier 5017*, both from Panama; *Langlassé 708*, from Guerrero, type of *H. tigrinus;* and *Botteri 1110*, from Vera Cruz, all have these characters of *Triumfetta* and are accordingly considered as not to belonging to the genus *Heliocarpus*.

An effort has been made to render the appended key available for herbarium use. Its artificiality is made necessary by the fact that many specimens will lack either fruits or flowers. I have followed Rose in the division of the group into those with stipitate and those with sessile fruits, but this character must be determined from the fruit, for the length of the ovarian stipe in even a mature flower is the same in both groups. After anthesis the stipe in the first group elongates, but in the second group no such elongation takes place.

CHARACTERS OF THE GENUS HELIOCARPUS

Trees or shrubs with stellate pubescence. Leaves simple, integral or lobed, petiolate, palmately veined. Inflorescence a panicle. Flowers polygamous or dioecious, four- or five-merous, sometimes apetalous, small, not more than 10 mm. long or broad, regular. Sepals valvate, acute, densely stellate, flat or hooded, often with a small appendage near the apex behind the hood. Petals alternate with the sepals, narrow, glandular, more or less pubescent toward the base. Receptacle with glands opposite the petals. Stamens fourtenn to forty, attached to the receptacle below the ovary, anthers introrse, opening by longitudinal slits, stamens often reduced to sterile filaments in pistillate flowers. Ovary wholly superior, more or less compressed, hairs on the compressed edge usually longer, two-celled, each cell with two ovules separated by a false partition. Style erect, filiform, not more than six or seven times the length of the ovary, bifid, the lobes spreading, simple and acute, or themselves lobed. Fruit indehiscent, *compressed, with a fringe of plumose hairs in two series around the compressed edge.*

Key to the species

Fruit sessile.
Leaves glabrous both sides or not more than slightly pubescent beneath.
Faces of fruit rugose, essentially glabrous, rays thinly plumose. 1. *H. glanduliferus.*
Faces of fruit more or less pubescent.
Faces slightly tomentose with some plumose hairs. 2. *H. pallidus.*
Faces not plumose, but short appressed stellate.
Fruit oval, rays longer than diameter of the body, body dark. 3. *H. occidentalis.*
Fruit orbicular, rays shorter than diameter of the body. 4. *H. polyandrus.*
Leaves more or less pubescent both sides, but especially beneath.
Mature leaves integral.

Fruit nearly or quite glabrous. 1. *H. glanduliferus*

Fruit unmistakably pubescent.

Fruit with a shallow groove between the cells, fringe less than diameter of the body, style longer than the ovary. 5. *H. Palmeri.*

Fruit densely tomentose, fringe much exceeding diameter of the body, style longer than the ovary. 6. *H. attenuatus.*

Mature leaves more or less lobed.

Upper surface minutely softly stellate, lower surface smooth, velvety, faces of fruit slightly pubescent, fringe less than diameter of the body. 7. *H. velutinus.*

Leaves more or less tomentose both sides, fringe equal to or longer than diameter of the body.

Leaves markedly reticulate beneath, style twice the length of the ovary, sepals tuberculate or appendaged. 8. *H. reticulatus.*

Leaves not markedly reticulate beneath, and sepals not appendaged.

Fruit clavate, faces densely hirsute, leaves densely stellate both sides. 9. *H. viridis.*

Fruit oval or orbicular, leaves tomentose beneath, faces of fruit with plumose hairs nearly as long as the fringe. 10. *H. terebinthinaceus.*

Fruit stipitate, so far as known.

Mature leaves with persistent stipules. 11. *H. stipulatus.*

Leaves without stipules.

Leaves with conspicuous appendages at the sinus. 12. *H. appendiculatus.*

Leaves without appendages.

Leaves glabrous or pubescent above, but with few to many long, appressed hairs.

Leaves integral, glabrous or glabrate above, densely tomentose beneath. 13. *H. tomentosus.*

Leaves lobed, often only obscurely.

Young stems, but not branches of the panicle, smooth and punctate with white dots, leaves irregularly serrate, lobes acuminate, blade seldom more than 15 cm. in length. 14. *H. americanus.*

Young stems not punctate with white dots, stems, petioles, and branches of the panicle usually flocculent or hirsute, blade of leaves more than 15 cm. long, appressed-stellate beneath. 15. *H. popayanensis.*

Leaves without long, appressed hairs above.

Lower surface thin, appressed-stellate and with conspicuous long, straight hairs on the sides of the nerves.	16. *H. australis.*
Lower surface otherwise.	
Leaves suborbicular, distinctly and acutely lobed, flowers strictly dioecious.	17. *H. diclinus.*
Leaves integral or lobed, flowers perfect or polygamous.	
Leaves essentially glabrous above and thin, appressed-stellate beneath.	18. *H. Donnellsmithii.*
Leaves more or less densely pubescent both sides.	
Pubescence of leaves in dense, separate tufts, larger and longer beneath, nerves not hirsute.	19. *H. rudis.*
Lower surface conspicuously long- and yellow-tomentose in the nerve axils.	20. *H. nodiflorus.*
Leaves otherwise.	
Leaves densely tomentose beneath.	21. *H. boliviensis.*
Leaves thin, appressed-stellate beneath, flowers in nodose clusters, style divided more than half way, leaves usually integral, at most obscurely lobed.	22. *H. Rosei.*

1. HELIOCARPUS GLANDULIFERUS Robinson; Rose, Contr. U. S. Nat. Herb. **5**: 127. 1897

H. glabrescens Hochr. Ann. Conserv. Jard. Bot. Genève **18-19**: 122. 1916.

Tree or shrub; young branches glabrate, minutely stellate, *densely clothed with small red glands;* leaves acute or acuminate, serrate, lower serrations glandular, glabrous or slightly pubescent above, lighter beneath, indument varying from essentially glabrous to densely and softly stellate, and villous on the principal nerve axils; panicle small, flowers in dense nodose clusters; sepals five, hooded, appendaged; petals linear, one-nerved, glandular, slightly stellate on the outside toward the base; stamens about twenty; style two and one-half times the length of the ovary, bifid briefly at the tip, lobes acute; fruit sessile, oblong, body 5 × 2 mm., slightly stellate on the faces, *becoming at length glabrous and rugose.*

TYPE: *Heyde 281*, Guatemala (U. S. National Herbarium and Gray Herbarium); *J. Donnell Smith 3956*, Guatemala; *Nelson 2400*, Chiapas; *Tonduz 8453*, Costa Rica; *Renson 61*, Salvador; *Galeotti 4154*, Vera Cruz (type of *H. glabrescens*); *Purpus 2227*, Vera Cruz.

2. HELIOCARPUS PALLIDUS Rose, Contr. U. S. Nat. Herb. 5: 128. 1897

Tree, 3.5–7.5 m. high; branchlets densely stellate-pubescent; leaves broad-ovate, integral or obscurely lobed, long-acuminate, 5–8 × 3–6 cm., base round, petiole 2–5 cm. long, dark green above, glabrescent, with a *very pale, dense, short, fine tomentum below*, three- to five-nerved, irregularly serrate; panicle open, spreading; sepals four or five, flat, appendaged; petals smaller, one-nerved, slightly stellate on both surfaces near the base; stamens about twenty; style about equal to the ovary, bifid about one-fifth of its length, lobes obtuse; fruit sessile, body *orbicular*, 3 mm. in diameter, faces densely stellate *with a few short plumose hairs*, fringe 4 mm. wide.

TYPE: *Palmer 191*, Chihuahua (U. S. National Herbarium); *Nelson 6970*, Guerrero; *Palmer 157*, Guerrero.

3. HELIOCARPUS OCCIDENTALIS Rose, Contr. U. S. Nat. Herb. 5: 127. 1897

Tree, 4.5–9 m. high; leaves integral, broadly ovate-lanceolate, base round, long-acuminate, obtusely serrate, above green, glabrescent, beneath densely but very finely, short, appressed-stellate; panicle large and spreading; sepals four or five, slightly hooded, short-appendaged; petals very small, obovate, entire, glandular, three-nerved, slightly stellate toward the base, especially on the edges; stamens about sixteen; ovary rather small; style as long as the ovary, bifid, lobes somewhat irregular; fruit sessile, body oval, *very dark*, faces rugose, *with separate stellate tufts*, 3.5 mm. wide, without plumose hairs, fringe 7 mm. wide, very plumose.

TYPE: in the U. S. National Herbarium, number not mentioned, *Palmer 440*, Guerrero; and *986*, Colima cited; *Langlassé 623*, Guerrero; *Pringle 10069*, Guerrero.

The fruit in this species is very characteristic, and the species shows little variability.

4. HELIOCARPUS POLYANDRUS S. Watson, Proc. Am. Acad. 21: 420. 1886

H. glaber Brandegee, Zoe **5**: 207. 1904.

H. laevis Rose, Contr. U. S. Nat. Herb. **8**: 317. 1905.

Tree or shrub; branchlets and petioles finely puberulent; leaves integral, ovate-lanceolate, cordate, acuminate, essentially glabrous above, slightly erect-stellate beneath, degree of pubescence variable, obtusely serrate; panicle small; sepals five, hooded and appendaged, 4 mm. long; petals linear-obovate, edges ciliate toward the base, five-nerved; stamens about forty; style much longer than the ovary, briefly bifid at the tip; *fruit orbicular, faces grooved between the cells,* stellate but without plumose hairs, fringe not longer than diameter of the body.

Type: *Palmer 100,* Chihuahua, Gray Herbarium; *Palmer 629,* Sonora; *Rose 1694,* Sinaloa.

Owing to variability of leaf-indument, the characteristic fruit is the final criterion of this species.

5. Heliocarpus Palmeri S. Watson, Proc. Am. Acad. **21**: 420. 1886

Shrub, 2.5–3.5 m. high; branchlets, also of the panicle, and petioles covered with very short stellate tomentum; leaves integral, broad-ovate, acuminate, mature ones subcordate, stellate-puberulent above, densely stellate but not tomentose below, more so on the nerves, 6–14 × 4–9 cm.; panicle leafy and diffuse; sepals five, hooded and appendaged; petals, in the pistillate flowers, none; stamens twenty, only a few sterile filaments in pistillate flowers; ovary much compressed; style shorter than the ovary, bifid, lobes spreading; fruit oblong or orbicular, 3 mm. in diameter, grooved between the cells, faces densely stellate but without plumose hairs, fringe dense, narrower than the diameter of the body.

Type: *Palmer 191,* Chihuahua, Gray Herbarium; *Palmer 97,* Chihuahua.

6. Heliocarpus attenuatus S. Watson, Proc. Am. Acad. **21**: 420. 1886

Shrub, 2.5 m. high; branches and petioles softly stellate; leaves integral, ovate-lanceolate, very long-acuminate, subcordate, rather small, not over 10 × 4 cm., softly and densely stellate but not tomentose, both sides, denser below; panicle rather short; flowers greenish yellow; sepals four or five, hooded, distinctly appendaged; petals linear, narrow, much shorter than the sepals, densely stellate on the outside toward the base, glandular; stamens about 18; ovary only slightly compressed; style twice the length of the ovary, bifid about one-fourth of its length, lobes spreading, acute; fruit oval, 3 mm. long, 2 mm. wide, faces densely hirsute-tomentose, not stellate or plumose, fringe longer than the length of the body.

Type: in the Gray Herbarium, number not mentioned; duplicate type, No. 1225, in the U. S. National Herbarium; *Palmer 99,* Chihuahua; *Palmer 647, 732, 733,* Sonora.

7. HELIOCARPUS VELUTINUS Rose, Contr. U. S. Nat. Herb. 8: 317. 1905

Tree, size not known; branches light brown, densely stellate; leaves three-lobed, suborbicular, about 13 cm. long and wide, cordate, lobes short but acute, upper surface with dense, but very short, fine, stellate tomentum, lower surface with an exceedingly dense and soft white tomentum, both surfaces velvety to the touch; panicle rather large; sepals flat, without appendages, other floral parts not seen; fruit oval, body 5 mm. long, 3 mm. wide, faces rugose, very thinly and softly stellate, fringe narrower than the width of the body.

TYPE: *Pringle 8694*, Morelos, U. S. National Herbarium.

8. HELIOCARPUS RETICULATUS Rose, Contr. U. S. Nat. Herb. 5: 128. 1897

H. microcarpus Rose, Ibid. **8**: 316. 1905.

Small tree; branchlets, also of the panicle, and petioles densely stellate; leaves broadly ovate, three-lobed, often obscurely, cordate, irregularly serrate, more or less densely stellate both sides and strongly reticulate below; panicle large and spreading in flower, but very compact in fruit; sepals five, slightly hooded, and tuberculate or short-appendaged at the apex; petals, often wanting, very small when present, glandular; stamens about twenty; ovary only slightly compressed; style two and one-half times the length of the ovary, bifid, each lobe having three very small acute lobes; fruit orbicular, faces about 3 mm. in diameter, densely tomentose, with many plumose hairs, fringe about as wide as the diameter of the body, becoming darker in color and much less tomentose with age.

TYPE: number not mentioned, but *Pringle 1791*, Jalisco, is cited. Here also belong: *Pringle 8227, 8719, 9692, 9693*, Morelos; *Rose & Painter 7389, 7390, 7537, 7646*, Jalisco; *Rose 3090, 2496*, Xacetecas, *Rose & Hough 4828*, Jalisco; *Nelson 3520*, Guatemala; *7046*, Guerrero; *Langlassé 572*, Guerrero; *Bourgeau 1200*, Morelos; *Goldman 1024*, Chiapas; *Mr. & Mrs. Lemmon 251*, Morelos.

There is a wide range of variation in the degree of pubescence of the leaves, and in the reticulation of the lower surface.

9. **Heliocarpus viridis** E. E. Watson, sp. nov.

Shrub or small tree; young stems light yellowish brown, longitudinally striolate, white-punctate, stellate-puberulent, smooth; leaves rather small, more or less three-lobed, lobes acute, three-nerved, concolor, crenate, upper surface slightly erect-stellate, lower surface similar but more densely stellate, especially on the nerves, short-petiolate, the smaller leaves subsessile; panicle small, open, peduncles mostly two-flowered, branches of the panicle densely fine-tomentose; flowers not seen; fruit sessile, oval, somewhat clavate, body 3 mm. long, 2 mm. wide, faces densely tomentose, light colored, fringe about 4 mm. wide.

TYPE: *Rose, Standley & Russell 12828*, Sonora, U. S. National Herbarium.

10. HELIOCARPUS TEREBINTHINACEUS (DC.) Hochr. Ann. Conserv. Jard. Bot. Genève, **18-19**: 125. 1916

H. Nelsoni Rose, Contr. U. S. Nat. Herb. **5**: 127. 1897.
Grewia terebinthinacea DC. Cat. Hort. Monsp. 114.

Shrub, 2.4–6 m. high; young parts scurfy pubescent; leaves broadly ovate, more or less three-lobed, lobes often acuminate, cordate, irregularly serrate, upper surface densely erect-stellate, the hairs in tufts of five or six, crisped, lower surface similar but denser, especially on the nerves, long-petiolate, petioles densely tomentose, blade 11–18 cm. long, 9–16 cm. wide; panicle compact, leafy; buds purplish; sepals four, slightly hooded but not tuberculate or appendaged, glandular; petals none in pistillate flowers; stamens sixteen, sterile in pistillate flowers; ovary slightly compressed, papillose-pubescent; style one and one-fourth times the length of the ovary, bifid about one-fourth of its length, lobes spreading and irregular; fruit only slightly compressed, almost equally covered by plumose hairs, a little shorter on the faces.

The type of *G. terebinthinacea* DC. is not mentioned, but the identity of the latter and *H. Nelsoni* Rose is based upon De Candolle's description of *Berlandier 1064* as *G. terebinthinacea* and its citation by Rose as *H. Nelsoni.* Rose's type of *H. Nelsoni* is *Nelson 1485*, Oaxaca, in the U. S. National Herbarium; *Nelson 1243, 1818*, Oaxaca; *L. C. Smith 937, 797*, Oaxaca; *Rose & Hough 4565*, Oaxaca; *Berlandier 1097*, Oaxaca; *Conzatti 1573*, Oaxaca.

11. HELIOCARPUS STIPULATUS Hochr. Ann. Conserv. Jard. Bot. Genève **18-19**: 121. 1916

H. americanus var. *popayanensis* Schum. in part. in Martius, Fl. Bras. **12**: 11. 1886.

Branches sordid-tomentose; leaves 10–14 cm. long by 9–11 cm. wide, broadly ovate, more or less three-lobed, *stipules persistent,* cordate, irregularly serrate, lower serrations glandular, upper surface dark, minutely stellate, glabrescent, nerves tomentose, lower surface lighter, deep green, slightly tomentose (under lens), nerves hirsute; panicles corymbiform; flowers almost sessile, bracts persistent; sepals four or five, linear, tuberculate; petals not much shorter than the sepals; ovary hirsute, style bifid more than half its length, the *androgynophore surrounded by a conspicuous pilose ring.* Fruit not seen.

TYPE: *Poeppig 3102*, Delessert Herbarium, habitat unknown.

I have not seen this specimen, but I strongly doubt the validity of its position in the germs *Heliocarpus*, particularly on account of the pilose ring about the androgynophore and the fact that the species was described without the fruit.

12. HELIOCARPUS APPENDICULATUS Turcz. Bull. Soc. Nat. Moscou **31**: 226, 1858

Probably a tree; young stems and branches of the inflorescence densely scurfy, flocculent-tomentose; leaves broadly ovate, sometimes obscurely and bluntly three-lobed, mature leaves with blade 17 cm. long and 15 cm. wide, long-petiolate, petioles with dense, short, sordid tomentum, upper surface dark green, punctate with short compact tufts, nerves slightly more so, lower surface much lighter, with dense short tomentum, irregularly serrate, base subcordate, *with two conspicuous appendages at the sinus;* panicle leafy and much branched, rather large; flowers very large for the genus; buds 6 mm. long; sepals 4, linear, flat, three-nerved, glandular; stamens about forty; ovary long-stipitate, narrowly oval; style shorter than ovary, deeply bifid, lobes spreading; fruit long-stipitate, oval or orbicular, body about 3 mm. long, faces densely hirsute-tomentose, but without plumose hairs, fringe 4–6 mm. wide, extending down the stipe.

TYPE: *Linden 2065*, Tabasco; *Maxon & Hay 3305, 3306, 3322*, Guatemala; *von Türckheim 7828, 8500*, Guatemala; *Rose & Hough 4314*, Vera Cruz; *Nelson 4385*, San Luis Potosi; *Collins & Doyle 255*, Chiapas.

There is some variability in the appendages at the sinus; usually they are oval or auriculate and entire, but occasionally they are serrate and glandular.

13. HELIOCARPUS TOMENTOSUS Turcz. Bull. Soc. Nat. Moscou **31**: 255. 1858

H. americanus var. *typica* Schum. in part, in Martius, Fl. Bras. **12**: 141.

Small tree; stems and young branches slightly stellate-puberulent; leaves ovate, integral, very rarely lobed, acuminate, base round, petiolate, seldom more than 11 cm. long and 8 cm.

wide, upper surface remotely stellate, with *few* to *many long, appressed, straight* hairs, lower surface densely tomentose, irregularly serrate, three- to five-nerved; panicle large and branched, the branches densely hirsute; sepals four, flat, unappendaged; petals linear, glandular, one-nerved, stellate toward the base on the outside, edges ciliate; stamens about fourteen; ovary small, papillose-pubescent, fringe very evident; style about twice as long as the ovary, bifid about one-fourth of its length; fruit stipitate, oval, body 3.5 mm. long, 2.5 mm. wide, faces densely hirsute, becoming less so with age, without plumose hairs, fringe 5 mm. wide, extending down the stipe.

TYPE: *Linden 857*, Tabasco.

This species is characterized by its leaves, very tomentose below and almost glabrous above. However, there is considerable variability in the indument of the leaves, particularly with regard to the long appressed hairs on the upper surface. These are sometimes entirely wanting, and yet often very abundant. Here belong: *Müller 884, 1049*, Vera Cruz; *Galeotti 4162, 4162B*, Vera Cruz; *Bourgeau 1574, 1719, 1815*, Vera Cruz; *Botteri 340, 341*, Vera Cruz; *Conzatti 1684*, Oaxaca; *Ervendberg 225*, Huasteca; *Goldman 37, 70*, Puebla; *Sutton Hayes 947, 1015*, Panama.

14. HELIOCARPUS AMERICANUS L. Sp. Pl. 448. 1753

H. americanus var. *popayanensis* Schum. in part, Martius, Fl. Bras. **12**: 141. 1886.

Shrub or small tree; young stems rather smooth, longitudinally striolate, punctate with white dots; leaves concolor, ovate, more or less three-lobed, subcordate, grossly and irregularly serrate, the ends of the smaller nerves marked by a larger serration in the leaf margin, lobes acuminate, blade seldom longer than 12 cm. or wider than 8 cm., upper surface glabrous except for many long, appressed straight hairs and minutely stellate nerves, lower surface thinly appressed-stellate, nerves and nervelets hirsute; panicle rather small and compact, branches sparsely hirsute and stellate; sepals five, hooded, very shortly appendaged; petals smaller, linear, one-nerved, glandular; stamens about sixteen; ovary compressed, papillose-pubescent, very wide at the base and sessile on the receptacle, although the fruit is stipitate, style a little shorter than the ovary, deeply bifid; fruit stipitate, body oval, 4 mm. long, 3 mm. wide, faces pubescent, becoming glabrate with age, a few of the hairs plumose, fringe about 5 mm. wide, extending down the stipe.

Linnaeus preserved no specimen. Here belongs *Fendler 1277 B*, Venezuela.

15. HELIOCARPUS POPAYANENSIS H. B. K. Nov. Gen. Sp. **5**: 341. 1821

H. trichopodus Turcz., Bull. Soc. Nat. Moscou **31**: 226. 1858.
H. americanus var. *popayanensis* Schum. in part in Martius, Fl. Bras., **12**: 141, 1886.
H. popayanensis var. *grandifolius* Hochr. Ann. Conserv. Jard. Bot. Genève **18–19**: 116. 1915.
H. popayanensis var. *Schumanni* Baker, Jour. Bot. **36**: 132. 1898.
H. popayanensis var. *Purdiei* Baker, l. c.
H. popayanensis var. *trichopoda* Baker, l. c.

Large tree; young stems and branches of the panicle and petiole usually *densely flocculent-stellate*, but often only hirsute or tomentose; leaves vary in form from integral, broadly ovate to acutely three-lobed, being often obscurely lobed, blade of mature leaves 16–20 cm. long, 13–18 cm. wide, minutely and sparsely stellateabove, more so on the nerves, and usually with *long, appressed* hairs, lower surface, densely appressed-stellate, the principal nerves often hirsute; panicle sessile, tri-radiate; sepals four, flat, unappendaged; petals long, linear-obovate, glandular, densely stellate toward the base; stamens about sixteen, ovary slightly compressed, style a little less than twice the length of the ovary, bifid about one-third of its length, the two lobes themselves somewhat lobed; fruit stipitate, body clavate, 4 mm. long, faces with short slender hairs, rarely a few plumose hairs among them, fringe about 4 mm. wide extending down the stipe.

TYPE: in Bonpland Herbarium, Paris, number not mentioned; *Holton 770*, Magdalena, Colombia; *Triand*, Bogota, Colombia; *Rose & Rose 23518*, Ventura, Ecuador; *Bang 1455*, Bolivia (type of var. *grandifolius*); *Fendler 1277*, Venezuela; *Cowell, 270, 271*, Panama; *Spruce*, eastern Peru.

This is a very variable species, and of wide geographical distribution. The variability of the leaves is observable in those of the same tree. The northern representatives are usually smoother than those from the vicinity of Popayan.

16. **Heliocarpus australis** E. E. Watson, sp. nov.

H. americanus var. *typica* Schum. in part in Martius, Fl. Bras. **12**: 141. 1886.

Probably a tree; young stems very smooth, branches of the panicle hirsute and finely appressed-stellate; leaves ovate-lanceolate, integral, very rarely lobed, base round, three-nerved, upper surface minutely stellate, older leaves almost glabrous, dark, lower surface thinly, appressed-stellate, but *conspicuously* *long-hirsute on the nerves especially at the sides,* regularly but doubly serrate; panicle rather large and much branched; sepals 4, linear, hooded, *tuberculate at the apex;* petals narrow, obovate, glabrous; stamens about sixteen; ovary small, compressed, faces papillose-pubescent, fringe very evident, style long, four times the length of the ovary, bifid about one-fourth of its length, lobes acute, spreading; fruit stipitate, oval, body 4 mm. long, 3 mm. wide, faces hirsute but without plumose hairs, becoming less so with age, fringe about 4 mm. wide extending down the stipe.

TYPE: *Hassler 557,* Paraguay, in the herbarium of the New York Botanical Garden; *Hassler 557a,* Paraguay; *Curran 9, 17, 700, 718,* Argentina.

17. HELIOCARPUS DICLINUS Hochr. Ann. Conserv. Jard. Bot. Genève **18-19**: 117. 1916

Shrub or tree; branches and young stems gray, puberulent; leaves orbicular, blade not more than 18 cm. long and wide, acutely three-lobed, often obscurely, upper surface *dark, finely stellate-puberulent,* lower surface *much lighter, densely, closely appressed-stellate,* nerves not hirsute; panicle rather small and compact, with *strictly dioecious* flowers on very short pedicels in dense, nodose clusters; buds and flowers very small; sepals four, slightly tuberculate; petals greatly reduced in pistillate flowers, 0.5 mm. long, stamens a few sterile filaments, ovary slightly compressed; style about as long as the ovary, bifid, lobes spreading; fruit not seen.

TYPE: *H. H. Smith 1908,* Santa Marta, Colombia.

18. HELIOCARPUS DONNELLSMITHII Rose; J. Donnell Smith, Bot. Gaz. **31**: 110. *pl. 1.* 1901

H. Caeciliae Loes.; Fedde, Rep. Spec. Nov. **12**: 227. 1913.

Small tree, 8–9 m. high; leaves integral, broadly ovate, short-acuminate, suborbicular at maturity, base round, finely serrate, lower serrations glandular, upper surface, *shining, essentially glabrous, lower surface remotely appressed-stellate,* stellations mostly with three or four rays, nerves slightly hirsute; panicle rather large, very loose, branches *finely stellate* and *slightly hirsute,* smooth; sepals four, slightly hooded, but not appendaged or tuberculate, 5 mm. long in perfect flowers, much smaller in pistillate flowers; petals long, obovate, one-nerved, the nerve dividing into three above, glandular, slightly stellate below on the outside, petals none in pistillate flowers; ovary small, slightly compressed, style three times the length of the ovary, bifid at the tip, ovary larger and style shorter, more deeply lobed in pistillate flowers; fruit stipitate, oval-orbicular, body about 2.5 mm. in diameter, faces densely hirsute, but without plumose hairs, fringe 4 mm. wide, extending down the stipe.

TYPE: *J. Donnell Smith 1722*, Guatemala. This species seems to be quite widely distributed. Here belong:—*Pére Duss 1367*, Martinique; *Curran 7*, Martinique; *Hahn 1340*, Martinique; *Baker 2490*, Nicaragua; *Kellerman 6068*, Guatemala; *Goll 255*, Guatemala; *Rovirosa 120*, Tabasco; *C. L. Smith 1002*, Vera Cruz.

19. **Heliocarpus rudis** E. E. Watson, sp. nov.

Tree, 15–25 m. high, bark smooth; young stems and branches of the panicle and petioles with *dense, ferruginous, tufted pubescence*, rough to the touch; leaves very broadly ovate, irregularly serrate, three-lobed but not deeply, often integral, lobes acute, deeply cordate, coarse in texture, very dark above, much lighter below, five- to seven-nerved, upper surface with *dense, separate, short, yellowish tufts* on the nerves and nervelets, lower surface with similar but *very much larger* tufts, and occasionally a tuft of four or five long, slender, flexible hairs 8–9 mm. in length, mature leaves 18 cm. long and wide, petioles 12 cm. long; panicle rather small; flowers unisexual or polygamous; pistillate flowers with 4 sepals, hooded and tuberculate, petals none, stamens a few sterile filaments; ovary slightly compressed, papillose-pubescent, fringe very evident, style a little longer than the ovary, bifid, each lobe dividing into three short acute lobes; staminate flowers not seen; fruit orbicular, short-stipitate, stipe less than 2 mm., body 4 mm. in diameter, faces rugose, slightly hirsute, with a few plumose hairs, about one-eighth as long as the fringe which is 5 mm. wide.

TYPE: *Pittier 3082*, Panama, in the U. S. National Herbarium.

20. HELIOCARPUS NODIFLORUS (Donnell Smith) Donnell Smith & Rose, Contr. U. S. Nat. Herb. **5**: 126. 1897

H. polyandrus var. *nodiflorus* Donnell Smith, Bot. Gaz. **23**: 240. 1897.

Tree; branches longitudinally striolate, very smooth, slightly stellate and hirsute, glabrescent; leaves integral, broad ovate, blade 18 × 14 cm. wide, often smaller, petioles 10 cm. long, doubly serrate, upper surface thinly stellate, more densely on the nerves, lower surface moderately dense appressed stellate, conspicuously dense, yellow, tomentose *in the nerve axils*, and at the attachment of the petiole, petioles glabrate, panicle rather small, leafy; flowers in *dense, nodose*, clusters; sepals four, hooded, tuberculate; petals smaller than sepals, four-nerved, very glandular, densely stellate below on both surfaces; ovary compressed, papillose pubescent, fringe very evident; stamens about twenty; style twice as long as ovary, briefly bifid; fruit long stipitate, body oval, 3 mm. in diameter, faces hirsute but without plumose hairs, fringe about 4 mm. wide, hairs of the fringe somewhat sinuous.

TYPE: *Heyde & Lux 4329* in part, Guatemala; *Heyde & Lux 4177,* Guatemala; *Heyde 637, 658,* Guatemala; *Nelson 3742* Guatemala.

21. HELIOCARPUS BOLIVIENSIS Hochr. Ann. Conserv. Jard. Bot. Genève **18-19**: 118. 1916.

Tree; young branches puberulent, punctate with white dots; leaves integral, often obscurely lobed, cordate or round at base; doubly serrate, lower serrations glandular, upper surface erect stellate, *particularly on the nerves*, dark; lower surface, lighter, densely tomentose; panicle large, leafy, branches pallid, brown pubescent, velvety; sepals four, hooded, slightly tuberculate at the apex, the tubercle being dark in color and *glabrous;* petals smaller, glandular; ovary compressed, pappilose pubescent, fringe evident, style as long as the ovary, deeply bifid; fruit stipitate, faces densely hirsute, without plumose hairs, (only immature fruit seen).

TYPE: *Bang 1491*, Bolivia.

22. HELIOCARPUS ROSEI Hochr. Ann. Conserv. Jard. Bot. Genève **18-19**: 119. 1916

Tree, 9 m. high; branches smooth, pilose; leaves integral, sometimes obscurely lobed, broad ovate, irregularly serrate, serrations remote and short, lower glandular, often glandular-appendiculate, blade often very large, 19 cm. long, 15 cm. wide; petioles rather short, not more than 8 cm.; upper surface minutely stellate, especially on the nerves, lower surface thinly stellate, stellations somewhat appressed, nerves slightly hirsute; panicle corymbiform, branches velvety; flowers in nodose clusters; sepals flat, not appendaged or tuberculate; petals long, obovate, glandular, three-nerved, slightly stellate at the base; stamens sixteen, filaments rather coarse, with an obvious nerve; ovary compressed, papillose-pubescent, style as long as ovary, *bifid almost its whole length;* fruit not seen.

TYPE: *Bang 2305*, Bolivia.

NOTE

23. HELIOCARPUS OBLONGIFOLIUS Turcz. Bull. Soc. Nat. Moscou. **36**: 226. 1858

Shrub; stems glabrous; leaves petiolate, ovate-oblong, acuminate, irregularly crenate, five-nerved, short stellate both sides; peduncles axillary, one-flowered. Habitat Brazil.

This very inadequately described species is reported from Brazil, exact location and collector being unknown to Turczaninow. No type is mentioned. I have not seen any specimen that fulfils the requirements of the description, and I consider the species very doubtful.

INDEX TO AMERICAN BOTANICAL LITERATURE

1921–1922

The aim of this Index is to include all current botanical literature written by Americans, published in America, or based upon American material; the word America being used in the broadest sense.

Reviews, and papers that relate exclusively to foresty, agriculture, horticulture, manufactured products of vegetable origin, or laboratory methods are not included, and no attempt is made to index the literature of bacteriology. An occasional exception is made in favor of some paper appearing in an American periodical which is devoted wholly to botany. Reprints are not mentioned unless they differ from the original in some important particular. If users of the Index will call the attention of the editor to errors or omissions, their kindness will be appreciated.

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Round, E. M. *Annularia* with *Paleostachya* fruit. Bot. Gaz. **73:** 326–328. *f. 1.* 15 Ap 1922.

A. Clarkii sp. nov.

St. John, H. A botanical exploration on the north shore of the Gulf of St. Lawrence including an annotated list of the species of vascular plants. Victoria Mem. Mus. **126:** 1–130. *f. 1 + map.* 25 Mr 1922.

Schwarze, C. A. The method of cleavage in the sporangia of certain fungi. Mycologia **14:** 143–172. *pl. 15, 16 + f. 1–6.* 6 Je 1922.

Setchell, W. A., & Gardner, N. L. Phycological contributions II–VI. Univ. California Publ. Bot. **7:** 334–427. *pl. 32–49.* 16 My 1922.

Includes new species in *Myrionema*, *Compsonema*, *Hecatonema*, *Pylaiella*,

Setchell, W. A., Goodspeed, T. H., & Clausen, R. E. Inheritance in *Nicotiana tabacum.* I. A report on the results of crossing certain varieties. Univ. California Publ. Bot. **5:** 457–582. *pl. 55–85 + f. 1, 2.* 14 Ap 1922.

Streblonema and *Ectocarpus.*

Sharma, P. D. The Mäule reaction as a means of distinguishing between the wood of angiosperms anf gymnosperms. Jour. For. **20:** 476–478. My 1922.

Shufeldt, R. W. Birds and flowers of early summer. Am. For. **28:** 283–289. *f. 1–10.* My 1922.

Shufeldt, R. W. From wild to garden flowers. Am. For. **28:** 347–353 + 364. *f. 1–11.* Je 1922.

Shufeldt, R. W. Trees and flowers in the U. S. Botanic Garden. Am. For. **28:** 225–231. *f. 1–9.* Ap 1922.

Skottsberg, C. Notes on Pacific coast Algae. II. On the Californian *Delesseria quercifolia.* Univ. California Publ. Bot. **7:** 427–436. *pl. 50.* 16 Je 1922.
Phycodrys Setchellii sp. nov.

Snell, W. H. A new *Septobasidium* on *Pinus strobus.* Mycologia **14:** 55–60. *pl 11–13.* 12 Ap 1922.
S. pinicola sp. nov.

Snell, W. H. Studies of certain fungi of ecomonic importance in the decay of building timbers. U. S. Dept. Agr. Bull. 1053: 1–47. *pl. 1–8 + f. 1–3.* My 1922.

Sprague, T. A. Plant nomenclature: a reply. Jour. Bot. **60:** 129–139. My 1922.

Stakman, E. C., Leach, J. G., Seal, J. L. Fruit and vegetable diseases. Univ. Minnesota Agr. Exp. Sta. Bull. 199: 7–75. *f. 1–38.* Ja 1922.

Stevens, O. A. New records and other notes on North Dakota plants. Bull Torrey Club **49:** 93–105. 18 My 1922.

Sudworth, G. B. A new chinquapin. Am. For. **28:** 300, 301. My 1922. [Illust.]
Proposes *Castanea pumila ashei* as new variety.

Tanaka, T. New Japanese fungi. Notes and translations—XI. Mycologia **14:** 81–89. 12 Ap 1922.

Thaxter, R. Reliquiae Farlowianae distributed from the Farlow Herbarium of Harvard University. Mycologia **14:** 99–103. 6 Je 1922.

Tottingham, W. E., & Rankin, E. J. Nutrient solutions for wheat. Am. Jour. Bot. **9:** 270–276. 21 Je 1922.

Trelease, S. F. Incipient drying and wilting as indicated by movements of coconut pinnae. Am. Jour. Bot. **9:** 253–265. 21 Je 1922.

Tukey, H. B. A case of pistillody and staminody in the plum. Torreya **22:** 28, 29. Mr–Ap 1922.

Van Hook, J. M. Indiana fungi. Proc. Indiana Acad. Sci. **1921:** 143–148. 1922.

Weatherby, C. A. Barratt, Torrey, Schweinitz: a correction and a discrepancy. Rhodora **23:** 300, 301. 22 Ap 1922.

W[eatherby], C. A. Is *Botrychium dissectum* a sterile mutant? Am. Fern Jour. **12:** 9–12. *f. 1.* 15 Je 1922.

Weatherby, C. A. On a supposed hybrid in *Equisetum.* Am. Fern Jour. **12:** 12–16. 15 Je 1922.

Weatherby, C. A. A new species of *Eleocharis* from Massachusetts. Rhodora **24:** 23–26. 23 My 1922.
E. fallax sp. nov.

Weatherby, C. A. Some amateur observations on color forms. Torreya **22:** 37–42. Je 1922.

Weatherwax, P. The popping of corn. Proc. Indiana Acad. Sci. **1921:** 149–153. 1922.

Weaver, J. E., Jean, F. C., & Crist, J. W. Development and activities of roots of crop plants. Carnegie Inst. Washington Publ. 316: 1–117. *pl. 1–14* + *f. 1–40* 11 My 1922.

Weber, G. F. Studies on corn rust. Phytopathology **12:** 89–97. *f. 1–3.* 25 Ap 1922.

Welles, C. G. *Cercospora* leaf spot of egg plant. Phytopathology **12:** 61–65. *f. 1–2.* 25 Ap 1922.
Cercospora melongenae sp. nov.

Wherry, E. T. Soil acidity preferences of some eastern [U. S.] conifers. Jour. For. **20:** 488–496. My 1922.

White, O. E. Brazil nuts. Brooklyn Bot. Gard. Leaflets **10:** 1–4. 17 My 1922.

Wiegand, K. M. Variations of *Carex annectens.* Rhodora **24:** 73, 74. 20 Je 1922.

C. annectens var. *xanthocarpa* n. comb.

Wilson, C. L. Lignification of mature phloem in herbaceous types. Am. Jour. Bot. **9:** 239–244. *pl. 13.* 21 Je 1922.

Wilson, E. H. Notes from Australasia—III. The Hobart Botanical Gardens. Jour. Arnold Arbor. **3:** 51–55. Jl 1921.

Wolf. F. A. Additional hosts for *Bacterium solanacearum.* Phytopathology **12:** 98, 99. 45 Ap 1922.

Wolf, F. A. A leafspot disease of tobacco caused by *Phyllostica nicotiana* E. and E. Phytopathology **12:** 99–101. 25 Ap 1922.

York, H. H., & Snell, W. H. Experiments in the infection of *Pinus strobus* with *Cronartium ribicola.* Phytopathology **12:** 148–150. 6 Je 1922.

Young, W. J. Potato ovules with two embryo sacs. Am. Jour. Bot. **9:** 213, 214. *f. 1.* 21 Je 1922.

Yuncker, T. G. Additions and corrections to the list of Indiana mosses. Proc. Indiana Acad. Sci. **1921:** 155, 156. 1922.

Yuncker, T. G. Three new species of *Cuscuta* from Mexico. Bull. Torrey Club **49:** 107–109. *f. 1–3.* 18 My 1922.

Cuscuta dentatasquamata, C. cozumeliensis, C. durangana spp. nov.

Vol. 50 No. 4

BULLETIN

OF THE

TORREY BOTANICAL CLUB

APRIL, 1923

A study of the embryo sac development and accompanying phenomena in Oenothera rubrinervis

CLAUDE E. O'NEAL

(WITH PLATES 5 AND 6 AND TWO TEXT FIGURES)

Since the announcement by De Vries at the beginning of the present century that *Oenothera Lamarckiana* was giving rise to new species by a process of mutation, the genus *Oenothera* has been subjected to a most thorough examination from almost every angle of botanical science. It has been a special favorite with the plant geneticists, and the morphologists and cytologists have found in its changing species a source of absorbing interest which has been maintained to the present time.

The notable cytological work of Gates (**14**), Lutz (**20**), and Davis (**5**, **6**) on the members of this genus was confined for the most part to the microsporocytes and root-tips of the species studied. The last mentioned, however, as well as Geerts (**15**) and, more recently, Ishikawa (**17**), touched upon the reduction divisions of the megaspore mother cells. As has been pointed out by Gates in this monograph and in other papers, the technical difficulties encountered in such a study are responsible for our present incomplete knowledge of this phase of the life cycle in the genus *Oenothera*.

The present paper has to do with the development of the embryo sac and attending phenomena of ovule development and fertilization in *Oenothera rubrinervis*. The first study of the embryo sac in *Oenothera* was made by Hofmeister (**16**) almost three quarters of a century ago. One of his figures shows the course of the branched pollen tube through the thick nucellar

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[The BULLETIN for March (**50**: 95–132. *pl.* 4) was issued March 16, 1923.]

structure and its entrance into the embryo sac. He stated that the embryo sac contained from two to four nuclei. He figured this condition for *Godetia*. About three decades after the appearance of Hofmeister's work Kny (**18**) published in his series of charts a description of the earlier phases of the development of the ovule in *Oenotheria biennis*. In 1908, Geerts (**15**) reported the absence of the antipodal cells and one polar nucleus in *Oenothera Lamarckiana;* and, in 1909, Modilewski (**21**) found the same condition in *Oenothera biennis, Circaea lutetiana*, and two species of *Epilobium*. This writer concluded that the tetranucleate embryo sac was a characteristic of the entire family. In 1914, Renner (**24**), working with *Oe. biennis, Oe. Lamarckiana, Oe. muricata* and various hybrids produced by crossing these species, confirmed the findings of Geerts and Modilewski and described fertilization and the early development of the embryo. The report of the tetra nucleate condition of the embryo sac received further confirmation in the same year by the work of Werner (**29**) upon *Oe. Lamarckiana, Oe. biennis, Oe, rhizocarpa, Oe. ietraptera*, and *Oe. coccinea*, as well as upon certain other members of the Onagraceae. The most recent work upon the embryo sac of *Oenothera* is that of Ishikawa* (**17**), who in 1918 published an exhaustive report of his study of this structure, as well as of the phenomena of fertilization in *Oe. nutans* and *Oe. pycnocarpa* (the *Oe. biennis* of the older literature).

OENOTHERA RUBRINERVIS

Oenothera rubrinervis was first described by De Vries (**27**), who found the plant appearing in sowings of *Oe. Lamarckiana*. Its presence was first noted by him in 1889. Before 1901 he had recorded its appearance 66 times as a mutant from *Oe. Lamarckiana*. Gates (**12**) mentions the fact that *rubrinervis*-like plants have been found growing wild in Newfoundland, as well as in western Colorado (**13**) and New Mexico. At first, De Vries considered *Oe. rubrinervis* a "fixed" species, but recently (**28**) he has called it a "half mutant." He thinks that it has been produced "by the copulation of a mutated gamete with a normal *velutina* gamete of *O. Lamarckiana*." In the same publication he showed that *Oe. deserens* is arising from his strain of *Oe.*

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* Ishikawa (**17**) and Gates (**12**) give extended bibliographies, which may be consulted for a general summary of the literature upon the genus *Oenothera*.

rubrinervis at the rate of about one to five. Gates (**13**) states that *Oe. rubricalyx* has arisen from *Oe. rubrinervis* by a mutation that is fundamentally chemical in its nature. He states that the difference between the two forms is chiefly one of amount of anthocyanin produced. Shull (**25**) attacked this position and showed by experimental evidence that it was erroneous. The plants with which the latter worked, however, were of uncertain ancestry and Gates insisted that they were hybrids. Lutz (**20**), who has made a cytological study of the species, makes a chromosomal distinction between the Amsterdam plant and the representatives found in Indiana. Davis (**8**) and others have stoutly maintained the hybrid origin of *Oe. Lamarckiana* itself. Davis (**4**) has been able to produce a plant resembling the small-flowered form of *Oe. Lamarckiana* by crossing *Oe. fransciscana* and the Dutch *Oe. biennis*. In his most recent paper on the subject (**8**), this writer states that *Oe. Lamarckiana* arose as a hybrid somewhere in Europe about the middle of the last century. In an earlier publication (**7**) he stated that "with but little doubt, it has come down to us, possibly greatly modified, from certain plants placed upon the market by the seedsmen Carter and Company, of London, about 1860." Gates (**13**) is inclined to accept the hybrid origin of *Oe. Lamarckiana* but is of the opinion that there is no evidence for thinking that its germinal instability has arisen from a single cross. De Vries originally assumed that *Oe. Lamarckiana* was a native American species. Leveillé (**19**),* in a publication which the writer has been unable to secure, states that *Oe. rubrinervis* reverts to *Oe. biennis*. As described by De Vries, the plants when young have leaves with red veins, stems with poorly developed bast fibers, and flowers with "stripes of red of varying width upon the sepals." Lutz (**20**) asserts that the Amsterdam plants have a tendency to produce flowers with crinkled edges, while the Indiana plants usually produce flowers with smooth edges.

The plants from which the material for this study was taken were grown from seed from an *Oe. rubrinervis* mutant that appeared in a sowing of *Oe. Lamarckiana* seed sent to Professor D. M. Mottier by DeVries in 1913. Pollination has been guarded,

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* Monographie du genre *Oenothera*. Le Mans. 1908. Review by S. B. Parish in Plant World **13**: 66–72.

and Professor Mottier has had the progeny under observation for nine generations. During this time the plants have been constant for the characters pointed out by De Vries. During the last two seasons, summers of 1920 and 1921, the writer has made a careful examination of the leaf forms in search of the *deserens* type, but no individuals have been found with unusually broad leaves. There is considerable variation in the time of flowering, as well as a slight color difference in the flowers, but certainly no more than is to be expected in the range of a single species. Our blossoms show the crinkled edges described by Lutz (**20**) for the Amsterdam plant. This character varies considerably with the individual plants and seems to be influenced by various climatic conditions.

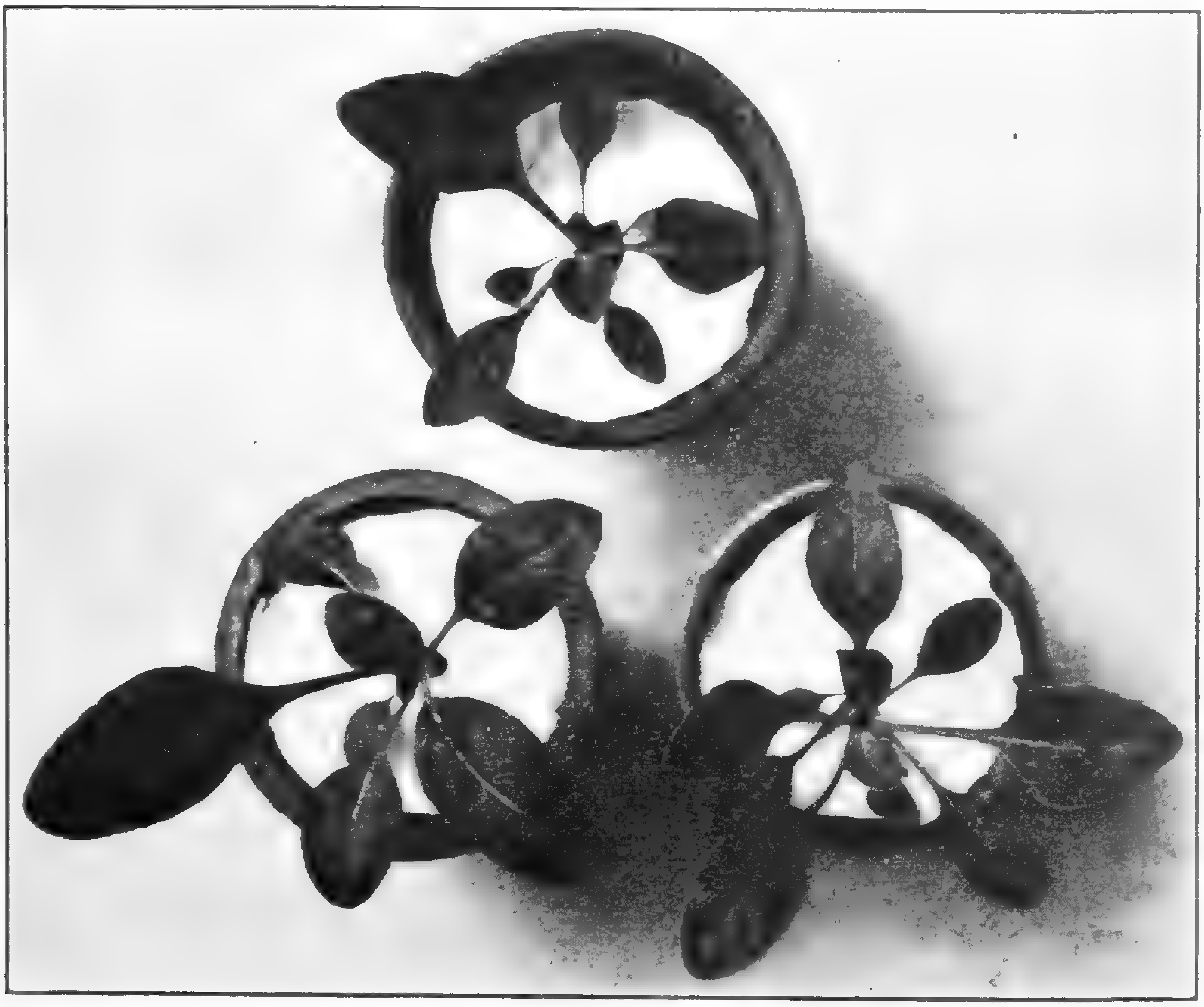

FIG. 1. Young seedlings of *Oenothera rubrinervis*.

The plants used in this study were grown from seeds sown in a box in the greenhouse in January. When the seedlings became more or less crowded they were set out in small pots and, after several transferals, they were transplanted about May 1 in the university garden, where they were staked to prevent breakage by the wind and given the usual cultivation. TEXT FIG. 1 shows three of our young plants with their usually shaped leaves.

Treatment of material.—The ovaries in various stages of development were partly stripped of their outer wall and dropped into the chromo-osmo-acetic solution. After two or three hours, they were transferred to a solution lacking the osmic acid, as recommended by Davis (**5**) for *Oenothera* material. For the younger stages of the development of the ovule, this treatment gives excellent results, but for the older stages, after the nucellus has become extensively developed, it is not so satisfactory. At this time the sporogenous cells are so deeply imbedded in the nucellar tissue that fixation is very difficult. For this part of the study a number of killing and fixing agents were tried out. The chromo-osmo-acetic mentioned above, Carnoy's fluid, corrosive sublimate acetic solution, and Bouin's fluid. Bouin's fluid, recommended by Gates (**10**) and used by Ishikawa (**17**), was found to give the best results and was used in securing all stages after the megaspore tetrad was formed.

After the usual method of dehydration and imbedding, sections 4–20 μ in thickness, depending upon the stage of development, were made and stained with anilin-safranin and gentian violet followed by orange G in clove oil. In all, 204 ovaries were cut and examined in sections. Considerable confidence is felt in the statements of development and attending conditions that are given below.

The ovule.—The ovule of *Oenothera rubrinervis* is of the usual anatropous type and is borne on the end of a short funiculus. One ovary was found in which the ovule-stalks were forked and bore two ovules. This abnormality may be added to the long list already noted by Gates (**9**) and others for the genus. At the time of fertilization the ovule is possessed of an outer integument composed of about four layers of cells and an inner one of from one to three layers. The integuments at this time entirely surround the large nucellus in which the embryo sac is deeply imbedded. The arrangement of the parts of the ovule at the time of fertilization is shown in TEXT FIG. 2. Placentation is central.

Early development of the ovule.—The anlage of the ovule is first noticed as a slight bulge or swelling on the wall of the loculus as shown in PLATE 5, FIG. 1. FIG. 2 shows a stage slightly more advanced, in which the hump is a little more pronounced. There is no evidence of cell differentiation at this time. FIG. 3, of a still later stage, shows a section of an ovule shortly before the appearance of the inner integument initials. FIG. 4 shows the initial development of the inner integument. In the same section the large hypodermal cell which functions as an archesporium may be observed. The occurrence of this cell in the development of ovules seems to have been noted first by Strasburger (**26**) in a plant which he did not name. It was found later by Mottier (**22**), who gave the former credit for first reporting it. Kny (**18**), in his series of charts that has been used extensively in college courses of botany, does not show this cell for *Oe. biennis*, but since the time of this publication, the cell has been observed repeatedly in other genera and Geerts (**15**) described it for *Oe. Lamarckiana*. FIG. 5 is of a section in which two hypodermal cells may be seen lying side by side. Such a condition will result in the formation of two embryo sacs lying side by side, as found by Ishikawa (**17**) in *Oe. pycnocarpa* and *Oe. nutans*.

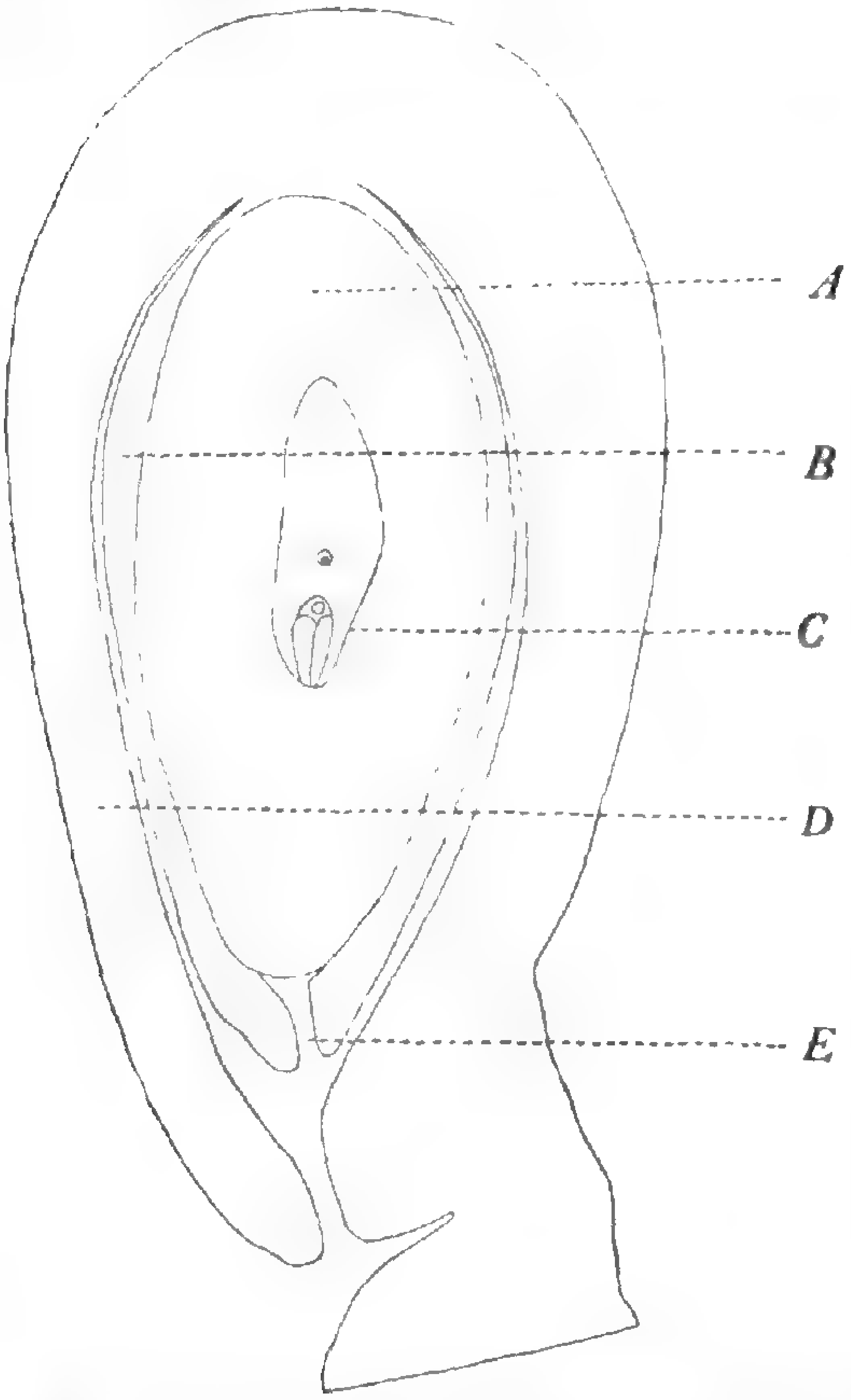

FIG. 2. A camera lucida diagram of the ovule of *Oenothera rubrinervis* showing the deeply imbedded embryo sac, C; the nucellus, A; the inner integument, B; the outer integument, D; and the micropyle, E.

The archesporial cell soon divides in a plane at right angles to its long axis into an outer cell that functions as a tapetum initial and an inner one that becomes the primary sporogenous, or megaspore mother cell, FIG. 6. Shortly after the division of the archesporial cell the initial development of the outer integument may be observed. FIG. 7 shows a section of an ovule in which the development of the outer integument is fairly well advanced.

As shown in FIGS. 1–6 the young ovule very early in its development appears bent upon its growing stalk. This curvature becomes accentuated as the integuments arise. As pointed out above, the inner integument begins as a single encircling row of cells that may be recognized by their larger size and location as well as by their subsequent behavior; the outer integument arises in a similar manner with the exception that, as shown in FIG. 7, the initial ring at first is not closed on the side next to the funiculus. FIG. 8 shows the ovule at the time that the integuments have just reached the end of the nucellus. In this ovule the outer integument completely surrounds the inner envelope of the nucellus. The megaspore mother cell with its large nucellus and dense cytoplasm is very prominent at this time and the developing tapetum, composed in this section of a row of three cells, may be made out also. In FIG. 9 a nucellus containing the large megaspore mother cell and a row of six tapetal cells is shown.

Development of the megaspore.—As shown in the figures, the large elongate megaspore mother cell is deeply imbedded in the nucellus. In some instances, when it begins to divide, a dozen cells may be counted in the tapetal row. The cell has pointed ends and a large nucleus. The cells at hand do not show the resting linin-chromatin reticulum well. While no consistent attempt was made to secure a complete set of mitotic figures in the division of this cell, practically all of those usually described have been found, and some of them, including that of synapsis shown in FIG. 10, were observed repeatedly. This condition in part at least may be due to faulty fixation. The chromosomes are usually in the form of short rods and look quite similar to those recently described by the writer (**23**) for *Datura*. They have been adequately described for this plant by Gates (**14**) in his study of the reduction division of the microsporocytes. The reduced number seems to be seven, as has been reported by other writers; at least, no more than this number could be found. The diminutive chromosome reported by Lutz (**20**) for the Amsterdam plant was not found in the material studied. FIG. 11 shows a reconstruction stage in which the chromosomes, connecting fibers, and anastomosing strands of cytoplasm stand out with particular clearness. FIG. 12 shows a little later stage in which the cell wall of the first division has been laid down. FIG. 13 shows a stage in the second division similar to that of the first division shown in FIG. 11. The four potential megaspores are shown in FIG. 14. Shortly after the formation of the megaspore tetrad one of the four cells begins the development of the megaspore. The cell nearest the micropyle is usually the functional one but, in some cases, the one at the opposite end of the row develops. This is the reverse of the condition found by Davis (**6**) in *Oe. biennis.* Geerts (**15**) reported that in *Oe. Lamarckiana* the cell nearest the micropyle is always the functional one of the tetrad. Ishikawa (**17**) found that in *Oe. pycnocarpa* and *Oe. nutans* the cell at one end of the row is just as likely to develop as the one at the other, and that either of the two intervening cells may develop, while in certain cases two of the cells in a tetrad may develop simultaneously. In *Oe. rubrinervis* the development of the cell towards the micropyle places the megaspore nearer the center of the nucellus. PLATE 6, FIG. 15, shows the condition of the ovule at the time the megasgore is being developed. The tapetum in this section is composed of eight cells which are still in the meristematic condition. Some sections show a greater amount of tapetal tissue than the one represented in the drawing. The figure does not show the outer integument.

Early in the development of the megaspore the nucleus migrates to the end of the cell next to the micropyle and a conspicuous vacuole appears. The nucleus remains in this position and the vacuole persists until the megaspore is mature. FIG. 16 shows a developing megaspore as well as the three disintegrating sister cells.

Germination of the megaspore.—FIG. 17 shows a longitudinal section of a mature megaspore in which the large nucleus and the central vacuole stand out prominently. This vacuole which appeared in the development of the megaspore is present until the embryo sac is matured. FIG. 18 shows the bi-nucleate stage of the embryo sac. This section is cut in such a way that the vacuole does not show, but a study of the adjoining sections reveals its presence. This stage of development follows shortly after that shown in FIG. 17, and the nuclei here shown divide almost immediately without changing position. This results in the tetra-nucleate condition shown in FIG. 19. Shortly after the formation of the four nuclei, plasma membranes appear around the cytoplasmic masses containing three of them and the usual egg apparatus with its two synergids and egg cell is formed, as shown in FIG. 20. The fourth nucleus usually draws away from the egg apparatus. While these changes have been taking place strands of cytoplasm have appeared in the vacuole, as is represented in the mature embryo sac given in the figure.

Coulter and Chamberlain (**3**) listed *Oenothera* in the group of plants having ephemeral antipodals. The present writer at the outset, knowing what an easy thing it would be to overlook the fragments of these cells, had the feeling that this was likely the condition. Literally thousands of sections have been examined for evidence supporting this view, but as stated above, the megaspore nucleus divides but twice, so the antipodals and one polar nucleus are completely lacking. This finding for *Oe. rubrinervis* is in keeping with that of Geerts (**15**) for *Oe. Lamarckiana*; Modilewski (**26**) and Ishikawa (**17**) for *Oe. biennis*; Renner (**24**) for *Oe. biennis, Oe. Lamarckiana, Oe. muricata*, and various hybrids produced by crossing these species; and Werner (**29**) for *Oe. Lamarckiana, Oe. biennis, Oe. rhizocarpa, Oe. tetraptera*, and *Oe. coccinea*.

The tetra-nucleate embryo sac.—The tetra-nucleate embryo sac has been reported for about sixty species of plants. Over half of these are from the order Myrtales, to which the Onagraceae belong. The tendency to this condition seems rather wide spread in the Archichlamydae and is found in the Orchidales and Liliales of the monocotyledonous group. Doubtlessly, the development of the tetra-nucleate embryo sac is but one expression of the tendency to eliminate the divisions that occur after the reduction division of the mother cell. A few cases have been reported from the Primulales, a lower order of the Metachlamydae; but, as has been pointed out by Coulter (**2**), it is doubtful if this tendency is a very strong one in this group.

Many of the orders in which the plants with four-nucleate embryo sacs are found have also species in which the antipodals are ephemeral. It is not clear how the latter condition could have given rise to the former. In the Myrtales, as well as in other orders in which the tetra-nucleate embryo sac has been reported, sacs with sixteen nuclei have been found. If there is a genetical relationship between these three conditions, it must be looked for in smaller groups. Ishikawa (**17**) says that the tetra-and sixteen-nucleate embryo sacs are to be regarded as representing a derived type, "probably caused by mutation and variation in certain stages of phylogenetic development." At the present stage of our knowledge this is probably as accurate a statement of the condition as it is possible for us to make.

Fertilization.—The ripe pollen grain as described by Geerts (**15**) for *Oe. Lamarckiana* has a generative cell and a tube cell. The division of the generative cell to form the sperms was not observed but it evidently occurs in the pollen tube. Sections were found showing the sperms and the tube nucleus in the tube. In most cases they are obscured by the large amount of starch present in the tube. In a pollen tube, the tip of which had just reached the embryo sac, the sperms and vegetative nucleus were observed in the part of the tube in the micropyle. Ishikawa (**17**) found that three sperms were formed in *Oe. pycnocarpa* and *Oe. nutans*. There are but two developed in *Oe. rubrinervis*. The sperms seem to enter the egg apparatus through a synergid as described by Ishikawa, but the material at hand does not show enough cases to be positively confirmatory on this point. The flowers from which the material for this paper were taken were guarded and at the proper time hand pollinated. It was found that with midsummer temperatures the pollen tubes were able to reach the embryo sac in about thirty-six hours after pollination and that fertilization (FIGS. 21, 22) occurred soon afterwards. In practice large masses of pollen were placed upon the stigmas. The large number of pollen tubes developed disrupted the inner tissue of the style to such a degree that the extent of their course could be made out by examining the styles with a binocular. But comparatively few of the tubes reached the micropyles. Numerous theories have been given for such failures. One mentioned by Compton (**1**) and based upon the supposed analogy between fertilization and infection in animals seems so unlikely as to warrant comment, even though out of the scope of this paper. According to this theory, the pollen tubes act as *antigens* and stimulate the formation of specific antibodies by the cells of the pistil. The outstanding objections to this belief are: (1) that there is no complete circulation in plants as in animals, so that but comparatively few cells could be stimulated, and (2) that the time between pollination and fertilization is too short for the development of anti-substances in sufficient quantities to produce such a striking effect, even if the circulation in plants were in all ways the same as in the higher animals.

Ishikawa (**17**) found that fertilization was double in *Oe. pycnocarpa* and *Oe. nutans* and Modilewski (**21**) reported it as probably double in *Oe. biennis*. The writer has been unable to confirm this finding in *Oe. rubrinervis* and has the feeling that it does not occur in this plant. The chromosomes were not counted in the endosperm and the whole point requires further investigation. It is needless to state that the *Oenotherae* do not furnish ideal material for fertilization studies.

SUMMARY

1. The ovules of *Oenothera rubrinervis* arise in the usual fashion from a slight swelling that appears upon the wall of the ovary.
2. Early in the development of the ovule an archesporial cell is differentiated that soon divides into an outer tapetal initial and an inner primary sporogenous cell.
3. The tapetum initial gives rise to a tapetal row of about a dozen cells, and the primary sporogenous cell develops into the usual potential megaspore tetrad.
4. The cell of the tetrad nearest the micropyle usually becomes the functional megaspore, although in some cases the one at the opposite end of the row may develop.
5. Early in the development of the megaspore, a large central vacuole appears which persists until after the embryo sac development is completed.
6. Upon germination the nucleus of the megaspore divides but twice, so that the mature embryo sac contains but four nuclei instead of the usual eight.

7. Fertilization occurs in about thirty-six hours after pollination and is probably single.

In conclusion, the writer is pleased to take the opportunity of acknowledging his debt of gratitude to Professor D. M. Mottier, of Indiana University, who assigned this problem and who, by friendly advice and encouragement, has aided much in bringing this paper to its present stage of completion.

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LITERATURE CITED

1. **Compton, R. H.** Phenomena and problems of self-sterility. New Phytol. **12**: 197–206. 1913.
2. **Coulter, J. M.** Relation of megasopres to embryo sacs in angiosperms. Bot. Gaz. **45**: 361–366. 1908.
3. **Coulter, J. M., & Chamberlain, C. J.** Morphology of angiosperms. New York. 1903.
4. **Davis, B. M.** A criticism of the evidence for the mutation theory of De Vries from the behavior of species of *Oenothera* in crosses and in selfed lines. Proc. Nat. Acad. Sci. **3**: 704–710. 1917.
5. ———. Cytological studies on *Oenothera*. I. Pollen development of *Oenothera grandiflora*. Ann. Bot. **23**: 551–571. *pl. 41, 42.* 1909.
6. ———. Cytological studies on *Oenothera*. II. The reduction divisions of *Oenothera biennis*. Ann. Bot. **24**: 631–651. *pl. 52, 53.* 1910.
7. ———. A much desired *Oenothera*. Plant World **16**: 145–153. *f. 1-4.* 1913.
8. ———. Species, pure and impure. Science II. **55**: 108–114. 1922.
9. **Gates, R. R.** Abnormalities in *Oenothera*. Rep. Missouri Bot. Gard. **21**: 175–184. *pl. 29-31.* 1910.
10. ———. A fixing fluid for plant tissues. Science II. **21**: 234. 1910.
11. ———. Heredity and mutation as cell phenomena. Am. Jour. Bot. **2**: 519–528. 1915.
12. ———. The mutation factor in evolution. London. 1915.

13. ———. Mutation in *Oenothera.* Am. Nat. **45:** 577–606. 1911.

14. ———. A study of reduction in *Oenothera rubrinervis.* Bot. Gaz. **46:** 1–34. *pl. 1–3.* 1908.

15. **Geerts, J. M.** Beiträge zur Kentniss der cytologischen Entwicklung von *Oenothera Lamarckiana.* Ber. Deutsch. Ges. **26a:** 608–614. 1908.

16. **Hofmeister, W.** Untersuchungen des Vorgangs bei der Befruchtung der Oenotheren. Bot. Zeit. **45:** 785–792. *pl. 8.* 1847.

17. **Ishikawa, M.** Studies on the embryo sac and fertilization in *Oenothera.* Ann. Bot. **32:** 279–317. *pl. 7* + *f. 1–14.* 1918.

18. **Kny, L.** Entwickeling der Samenknospe von *Oenothera biennis* L. Bot. Wandtafeln 53-55. *pl. 19.* Berlin. 1876.

19. **Leveille, A.** Monographie du genre *Oenothera.* Le Mans. 1908.

20. **Lutz, Anne M.** *Oenothera* mutants with diminutive chromosomes. Am. Jour. Bot. **8:** 502–526. *pl. 24.* 1916.

21. **Modilewski, J.** Zur Embryobildung von einigen Onagraceen. Ber. Deutsch. Ges. **27:** 287–292. *pl. 27.* 1909.

22. **Mottier, D. M.** On the development of the embryo sac of *Arisaema triphyllum.* Bot. Gaz. **17:** 258–260. *pl. 1.* 1892.

23. **O'Neal, C. E.** Microsporogenesis in *Datura Stramonium.* Bull. Torrey Club. **47:** 231–242. *pl. 8, 9.* 1920.

24. **Renner, O.** Befruchtung und Embryobildung bei *Oenothera Lamarckiana.* Flora **107:** 115–149. *pl. 12, 13.* 1914.

25. **Shull, G. H.** A peculiar negative correlation in *Oenothera* hybrids. Jour. Gen. **4:** 1914.

26. **Strasburger, E.** Die Angiospermen und die Gymnospermen. Jena. 1879.

27. **Vries, H. de.** Species and varieties—their origin by mutation. Chicago. 1905.

28. ———. *Oenothera rubrinervis,* a half mutant Bot. Gaz. **67:** 1–26. 1919.

29. **Werner, E.** Zur Oekologie atypischer Samenlagen. Beih. Bot. Centralbl. **32**^{1}**:** 1–14. *f. 1–19.* 1914.

Explanation of plates 5 and 6

PLATE 5

FIG. 1. The anlage of the ovule before cell differentiation has begun, × 350.

FIG. 2. A slightly later stage, × 350.

FIG. 3. The young ovule shortly before the appearance of the inner integument initials, × 350.

FIG. 4. A young ovule in which the primordial cell and the inner integument initials are shown, × 350.

FIG. 5. A stage similar to that shown in FIG. 4, in which two primordial cells may be seen lying side by side, × 350.

FIG. 6. A slightly later stage in which the tapetal initial and the primary sporogenous cells resulting from the division of the primordial cell are shown, × 350.

FIG. 7. An early stage in the development of the outer integument, × 350.

FIG. 8. A young ovule showing the large megaspore mother cell, nucellus with the developing tapetum, and the inner and outer integuments, × 200.

FIG. 9. The nucellus of a latter stage in which a megaspore mother cell and a row of six tapetal cells are shown, × 350.

FIG. 10. A megaspore mother cell in the synaptic condition, × 740.

FIG. 11. A megaspore mother cell in the late telophase of the first division, × 740.

FIG. 12. The two daughter cells resulting from the first division of the megaspore mother cell, × 740.

FIG. 13. A late telophase of the second division of the second division of the megaspore mother cell, × 740.

FIG. 14. A megaspore tetrad, × 740.

PLATE 6

FIG. 15. A nucellus surrounded by the inner integument and containing the developing megaspore and a tapetum of eight cells which are still in the meristematic condition, × 200.

FIG. 16. The young megaspore, with its large nucleus and central vacuole, and the three disintegrating cells, × 740.

FIG. 17. A mature megaspore, × 740.

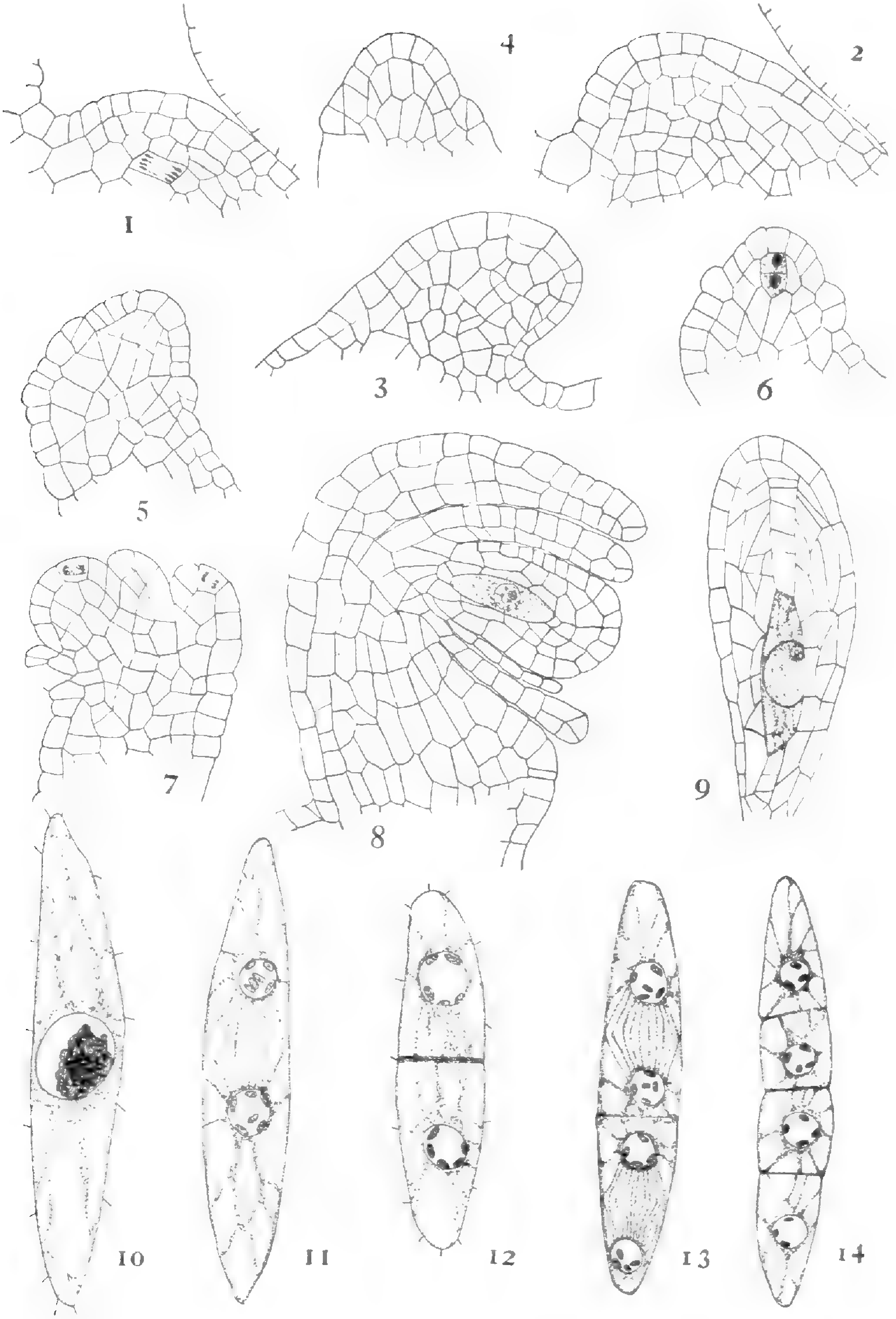
FIG. 18. A binucleate stage of the embryo sac, × 740.

FIG. 19. A developing embryo sac with four free nuclei, × 740.

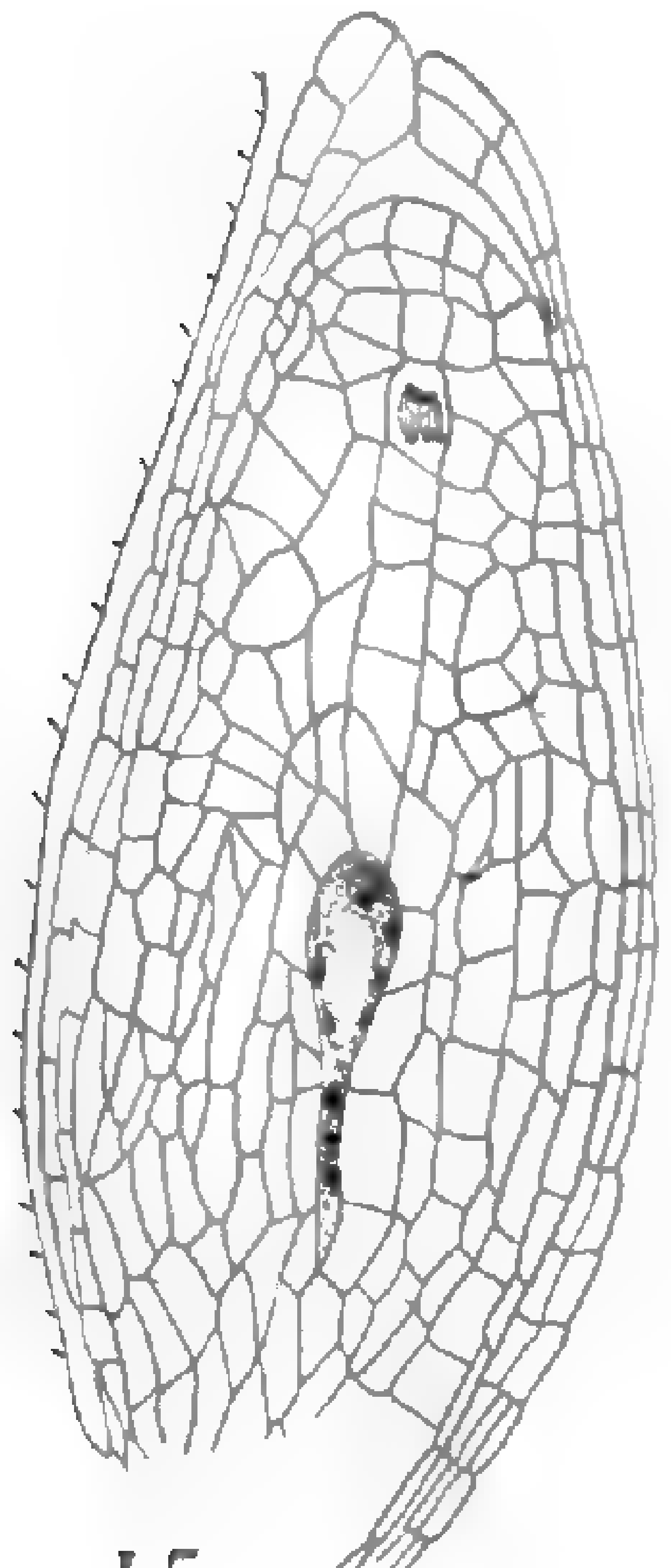
FIG. 20. A mature tetra-nucleate embryo sac, × 740.

FIG. 21. A fertilization stage, × 1200.

FIG. 22. A fusion of the (larger) egg cell nucleus and the nucleus of the sperm (somewhat idealized), × 1800.



O'NEAL: OENOTHERA RUBRINERVIS



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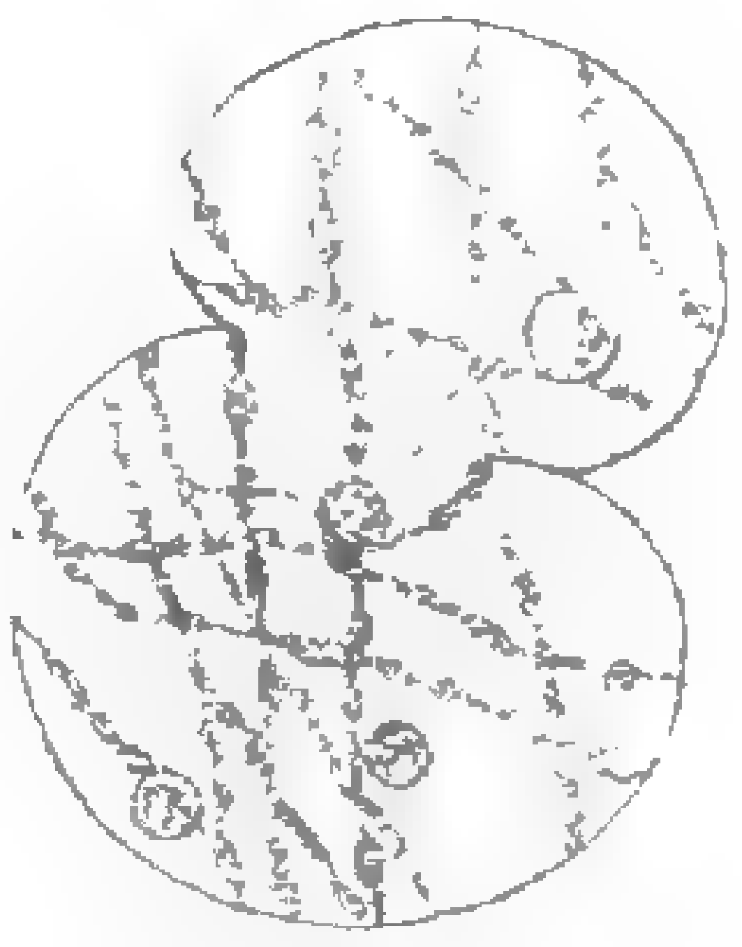

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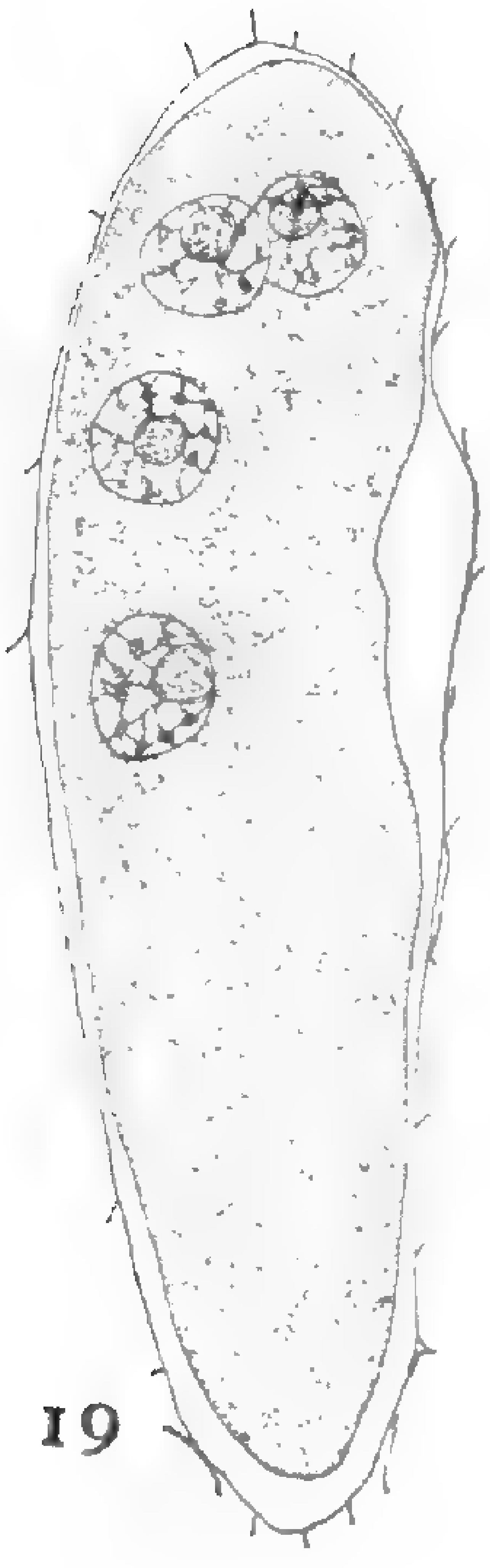

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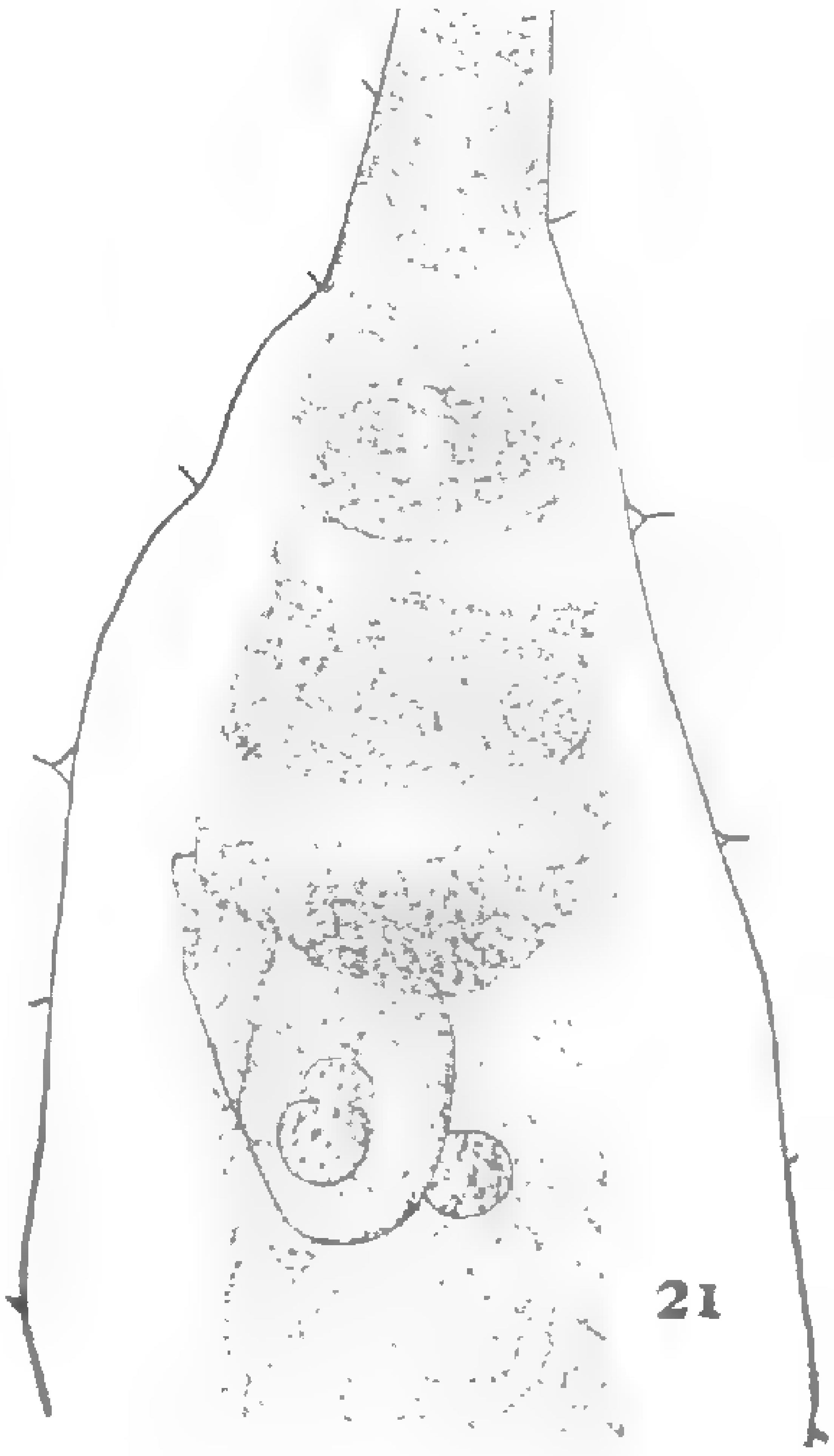

21

O'NEAL: OENOTHERA RUBRINERVIS

Windsorina, a new genus of Rapateaceae

HENRY ALLAN GLEASON

(WITH PLATE 7)

The small family Rapateaceae is still one of the most poorly known groups of South American plants. Seubert knew but three genera and six species when he monographed the group for the Flora Brasiliensis in 1847. At approximately the same period the Schomburgk brothers were exploring British Guiana actively and brought out other remarkable species from the dense forests of that region, and Spruce contributed still other novelties from northern Brazil and southern Venezuela. Körnicke summarized the existing knowledge of the family in 1873, and his treatment remains the latest monograph. The greatly condensed discussion given the family by Engler in 1888 indicates that it was still scantily represented in continental herbaria, although Bentham and Hooker seem to have had fairly abundant material at hand when they published Genera Plantarum in 1883. It is still poorly illustrated in American herbaria, because of lack of recent exploration in the hinterland of the Guianas and Brazil, although the recent collections of Hitchcock, Gleason, and De La Cruz have included several of the coastal species.

The characters and history of the family were published in detail by Körnicke and need no re-statement. The distinction of genera lies chiefly in the structure of the anthers and the nature of the inflorescence. The latter is invariably a head or a headlike umbel, is usually subtended by an involucre of one or two foliaceous bracts, and is borne on a long peduncle arising from the base of a leaf and protruding from within the leaf-sheath.

On June 27, 1921, the writer was walking through the six miles of dense tropical forest between Kangaruma and Potaro Landing, on the Potaro River, British Guiana. His attention was attracted by a gregarious plant with broadly linear leaves, growing in a small marsh along the trail and apparently sterile. Closer examination showed that each plant bore numerous long peduncles, arising in fascicles from one or more of the leaf-sheaths and terminating in a subcapitate cluster of bracted flowers. Subsequent examination and comparison with the material at the New York Botanical Garden demonstrated beyond a doubt that the plant was a member of the Rapateaceae and that it could not be assigned to any of the seven genera hitherto recognized.

WINDSORINA gen. nov.

Herba glabra paludosa Rapateacearum; pedunculi axillares fastigiati 3–9; inflorescentia terminalis subumbellata sine involucro; flores pedicellati circa 10–20 ovoidei bracteis imbricatis 9–12 suffulti; calyx erectus, sepalis 3 convolutis; petala 3 libera limbo ovato flavo; stamina 6, filamentis liberis ante anthesin brevibus post anthesin contortis, antheris quadrilocularibus lineari-lanceolatis poro obliquo subterminali apertis; capsula ovoideo-prismatica loculicida trilocularis, seminibus in loculo solitariis subglobosis albis dorso maculatis ad apicem cartilagine appendiculatis.

Windsorina guianensis sp. nov.

Herba 1 m. alta gregaria; foliorum vagina lineari, lamina late lineari multinervia venosa; pedunculis longis erectis angulato-compressis angustis sursum sensim clavatis; pedicellis 5–15 mm. longis; bracteis inferioribus lanceolatis acuminatis, mediis ovatis acutis, superioribus oblongo-obovatis; sepalis lanceolatis erectis post anthesin clausis; petalorum limbis ovatis; filamentis planis; capsula straminea; seminibus minute rugulosis.

The type is *Gleason 272*, deposited in the herbarium of the New York Botanical Garden.

Since Schomburgk named a genus, *Saxo-Fridericia*, and a species, *Rapatea Friderici-Augusti*, in honor of a contemporary German ruler, the present generic name *Windsorina* is given in commemoration of the House of Windsor of Great Britain.

Windsorina guianensis is essentially acaulescent, as are all other members of the family, bearing several erect or ascending leaves which reach a height of a meter. Of this length, the lower fifth or fourth is flattened into a sheath, bearing the midvein on one side and not in the center, and about 25 mm. wide. At the summit of the sheath, the leaf contracts to 10 mm. wide, and then expands into the broadly linear, acuminate blade, which is 50–75 mm. wide. As in all Rapateaceae, the blade bears a peculiar relation to the sheath. The midvein of the latter is prolonged into the midvein of the blade, the back of the sheath becomes the margin at the point of constriction and is thence continued as one margin of the blade, which is itself slightly inequilateral. The blade contains numerous longitudinal ribs, arising from the midvein, running almost parallel to it, and connected by numerous transverse veinlets.

From the axils of some of the leaves arise clusters of three to nine erect peduncles as much as 6 dm. long, more or less fastigiate at the base, and subtended by a few narrowly lanceolate, colorless, scarious, one-nerved, acuminate scales 30–55 mm. long. Other members of the family have normally solitary peduncles, although Körnicke mentions that two may sometimes occur. They are strongly angled, at least when dry, and double or treble their diameter toward the apex. The inflorescence proper is a capitate umbel, bearing ten to twenty flowers. The lowest of these is not subtended by a bract, and is borne on the longest pedicel, which may be 12 mm. long and appears almost as a continuation of the stem. On the opposite side of the umbel is a scarious, ovate-lanceolate, acute bract 10–15 mm. long. When the lowest flower and lowest bract are removed, a second bractless flower is discovered, situated opposite a second bract. Each of the remaining flowers in turn is on a shorter pedicel, until the central flowers of each umbel are almost sessile, and the respective bracts also decrease regularly in size. In the bracteal characters, *Windsorina guianensis* differs from other members of the family. Two bracts only occur in five of the genera: in three genera these are separate, in *Rapatea* they are barely connate at base, and in the little-known *Saxo-Fridericia* they are connate throughout into an enclosed cone surrounding the flowers and broken by them at or before anthesis. In one genus, *Spathanthus*, there is a single bract, which is adnate to the axis of the spicate inflorescence and closely simulates the spathe of an aroid. In *Stegolepis* the involucre is completely lacking. If the bracts of *Windsorina* are regarded as appertaining to each flower, and not as constituting an involucre to the whole umbel, differences from the other genera are again apparent, for such bracts have been observed, according to Körnicke, only in *Rapatea*, in which the true involucre is particularly well developed. In the pedicelled flowers, *Windsorina* agrees only with *Rapatea*.

The flowers become 7–8 mm. long at maturity and are subtended and almost enclosed by nine to twelve smooth brownish-yellow bracts. Of these, the lowest is the smallest and is long-acuminate into a slender subulate tip; the second is abruptly acuminate into a short tip, while the upper ones are obtuse or barely acute and somewhat thickened at the apex. Their shape also changes progressively, the outer being lanceolate, the middle elliptic, and the innermost oblong-obovate. Their size ranges from 3 to 5 mm. long by 1–2 mm. wide.

When the bracts have been removed one by one, the three sepals are finally exposed. They are similar to the bracts in color and texture, ovate-lanceolate, acute, 5–6 mm. long, 2 mm. wide, and closely rolled together after anthesis.

Körnicke noted the great rarity of expanded corollas in all the dried material of this family. Among the scores or even hundreds of growing plants of *Spathanthus unilateralis* and *Rapatea paludosa* observed by the writer in British Guiana, only one exhibited an open corolla, and on fifty or more fertile plants of *Windsorina* not one open corolla was noted. It is probable that the family in general is characterized by a short period of anthesis, the petals expanding quickly, remaining open for a short time only, and then wilting and contracting back into the calyx. Dissections of unopened buds show three yellow triangular-ovate petals with basal colorless claws, the whole about equaling the sepals. After anthesis, the claw is found to be considerably longer and the limb is recurved, more or less contorted, and faded to brown. Unopened stamens have short, colorless, flat, ovate-oblong filaments less than 1 mm. long, which after anthesis are 5–6 mm. long and greatly contorted into several folds or loops. The anthers are yellow, lanceolate in outline, about 3 mm. long, and quadrilocular, the two inner loculi extending only about three-fifths of the distance to the apex, above which point the anther is conspicuously narrower. It opens by a small pore on the inner surface just below the apex. This becomes visible only after anthesis, when the whole anther is shriveled and the empty pollen-sacs bright reddish brown.

The structure of the anthers is of considerable taxonomic importance in the Rapateaceae. In *Cephalostemon* and *Saxo-Fridericia* they open by a terminal longitudinal cleft, in *Schoeno-*

cephalium by two terminal pores, in *Rapatea* by a pore in a terminal appendage, in the remaining four by a single oblique terminal pore. Among these four, *Windsorina* is distinguished by its pedicelled flowers on fastigiate peduncles, its lack of a true involucre, as well as characters of the fruit.

The ovary is broadly ovoid or subglobose, truncate at the apex, white in color, and with three rounded lobes. The style is slender and about 3.5 mm. long. The fruit is a broadly ovoid-prismatic, loculicidal, three-celled, yellow capsule, not exceeding the subtending calyx in length. Each valve is thin and scarious at the base but stiff and coriaceous above, ovate-rhombic in shape, and with a broad rounded notch at the apex. There is a single ovule in each cavity. The ripe seed is nearly globose, but somewhat flattened on the inner surface. On the outer surface, the chalaza is indicated by an oval brown spot near the apex, above which the seed bears a flattened, narrowly triangular, brownish-yellow appendage nearly 1 mm. long. The testa is white, shining, and minutely rugose. In the characters of the fruit *Windsorina* agrees with *Monotrema*, *Rapatea*, and *Cephalostemon*; in *Spathanthus* the fruit is unilocular by abortion, and in the other three genera the ovules are two or more in each loculus.

The eight genera may be separated as follows:

Flowers pedicelled.	
Peduncles numerous; involucre none	*Windsorina.*
Peduncles solitary; involucre of two bracts	*Rapatea.*
Flowers sessile.	
Involucre none	*Stegolepis.*
Involucre of a single bract, spathe-like	*Spathanthus.*
Involucre of two bracts united into a hollow cone	*Saxo-Fridericia.*
Involucre of two free bracts.	
Anthers opening by a terminal slit	*Cephalostemon.*
Anthers opening by a terminal pore	*Monotrema.*
Anthers opening by two terminal pores	*Schoenocephalium.*

NEW YORK BOTANICAL GARDEN

Explanation of plate 7

WINDSORINA GUIANENSIS Gleason

1. Inflorescence, natural size. 2. Single flower, × 4. 3. Petals before and after anthesis, × 5. 4. Stamens before and after anthesis, × 5, *d*, dorsal, *v*, ventral, and *l*, lateral views. 5. Pistil, × 5. 6. Mature fruit, × 6. 7. Seeds, × 6.

WINDSORINA GUIANENSIS Gleason

INDEX TO AMERICAN BOTANICAL LITERATURE

1921-1922

The aim of this Index is to include all current botanical literature written by Americans, published in America, or based upon American material; the word America being used in the broadest sense.

Reviews, and papers that relate exclusively to foresty, agriculture, horticulture, manufactured products of vegetable origin, or laboratory methods are not included, and no attempt is made to index the literature of bacteriology. An occasional exception is made in favor of some paper appearing in an American periodical which is devoted wholly to botany. Reprints are not mentioned unless they differ from the original in some important particular. If users of the Index will call the attention of the editor to errors or omissions, their kindness will be appreciated.

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Adamstone, F. B. Myxomycetes of the Lake Nipigon district. Canadian Field Nat. **36:** 129-131. O 1922.

Allen, E. J. The progression of life in the sea. Am. Nat. **56:** 481-503. D 1922.

Allen, W. E. Quantitative studies on inshore marine diatoms and dinoflagellates of southern California in 1920. Univ. California Publ. Zool. **22:** 369-378. 22 D 1922.

Allen, W. E. Quantitative studies on marine phytoplankton at La Jolla [California] in 1919. Univ. California Publ. Zool. **22:** 329-347. *f. 1, 2.* 22 D 1922.

Ames, O. Studies in the family Orchidaceae—VI. pp. 1-174. Boston. 1922. [Illust.]
Includes descriptions of many new species.

Ames, O. Studies in the family Orchidaceae—VII. pp. 1-335. Boston. 1922. [Illust.]
Includes descriptions of many new species.

Anderson, E. G. Heritable characters of maize—XI. Finestreaked leaves. Jour. Hered. **13:** 91, 92. *f. 21.* 7 S 1922.

Andrews, A. L. *Hymenostomum* in North America—II. The case of *Astomum Sullivantii.* Bryologist **25:** 66–71. 31 Jl 1922.

Andrews, F. M. *Spirogyra.* Proc. Indiana Acad. Sci. **1921:** 87–89. *f. 1, 2.* 1922.

Arber, A. Leaves of the Farinosae. Bot. Gaz. **74:** 80–94. *pl. 1–3.* S 1922.

Arbuckle, H. B., & Thies, O. J. Variation of protein content of corn. Jour. Elisha Mitchell Soc. **38:** 84–87. S 1922.

Arrhenius, O. Absorption of nutrients and plant growth in relation to hydrogen ion concentration. Jour. Gen. Physiol. **5:** 81–88. *f. 1–6.* 20 S 1922.

Arthur, J. C. Aecidiaceae (continuatio). N. Am. Fl. **7:** 481–540. 11 D 1922; 541–604. 20 D 1922.

Arthur, J. C. New species of Uredineae—XIV. Bull. Torrey Club **49:** 189–196. 10 Au 1922.

Includes *Diabole,* gen. nov., and new species in various genera.

Arthur, J. C., & Bisby, G. R. *Teleutospora.* N. Am. Fl. **7:** 516–520. 11 D 1922.

Arthur, J. C., & Jackson, H. S. *Micropuccinia.* N. Am. Fl. **7:** 521–586. 11 D. 1922.

Arthur, J. C., & Mains, E. B. *Bullaria.* N. Am. Fl. **7:** 482–515. 11 D 1922.

Ashby, S. F. Oospores in cultures of *Phytophthora Faberi.* Kew Bull. Misc. Inform. **1922:** 257–262. N 1922.

Ashe, W. W. *Azalea* in North Carolina. Jour. Elisha Mitchell Soc. **38:** 90, 91. S 1922.

Ashe, W. W. Notes on trees and shrubs of the southeastern United States. Bull. Torrey Club **49:** 265–268. 22 S 1922.

Atwood, W. M. Physiological studies of effects of formaldehyde on wheat. Bot. Gaz. **74:** 233–263. 23 N 1922.

Bailey, I. W. The anatomy of certain plants from the Belgian Congo, with special reference to myrmecophytism. Bull. Am. Mus. Nat. Hist. **45:** 585–621. *pl. 30–45.* 21 O 1922.

Bailey, I. W. Notes on neotropical ant-plants—I. *Cecropia angulata,* sp. nov. Bot. Gaz. **74:** 369–391. *pl. 15 + f. 1–8.* 21 D 1922.
New species from British Guiana.

Bailey, I. W. The pollination of *Marcgravia*: a classical case of ornithophily? Am. Jour. Bot. **9:** 370–384. *pl. 23, 24 + f. 1–5.* 30 Au 1922.
Describes two new species from Guiana.

Ballard, W. S., Magness, J. R., & Hawkins, L. A. Internal browning of the yellow Newton apple. U. S. Dept. Agr. Bull. 1104: 1–24. *pl. 1, 2.* 23 O 1922.

Barker, E. E. A note from the Okefinokee swamp [Georgia]. Torreya D 1922.

Barnhart, J. H. Plant nomenclature. Jour. Bot. **60:** 256–263. S 1922.

Bartlett, G. H. *Senecio obovatus,* var. *elongatus* in Connecticut. Rhodora **24:** 226. 4 D 1922.

Bartlett, H. H. Color types of *Corallorrhiza maculata* Raf. Rhodora **24:** 145–148. 11 S 1922.

Bartram, E. B. Midwinter botanizing in southern Arizona. Bull. Torrey Club **49:** 237–251. 31 Au 1922.

Bartram, E. B. Some Nova Scotia mosses. Rhodora **24:** 121–124. 28 Au 1922.

Bauer, F. C., & Haas, A. R. C. The effect of lime, leaching form of phosphate and nitrogen salt on plant and soil acidity, and the relation of these to the feeding power of the plant. Soil Sci. **13:** 461–480. *pl. 1 + f. 1–8.* Je 1922.

Belling, J., & Blakeslee, A. F. The assortment of chromosomes in triploid daturas. Am. Nat. **56:** 339–346. *f. 1–8.* Au 1922.

Benedict, R. C. A fern society campaign for wild plant conservation. Am. Fern Jour. **12:** 131–133. 30 D 1922.

Benedict, R. C. Game laws for ferns and wild flowers. Am. Fern Jour. **12:** 33–45. *pl. 2.* 11 S 1922.

Benson, M. *Heterotheca Grievii*, the microsporange of *Heterangium Grievii.* Bot. Gaz. **74:** 121–142. *pl. 4, 5 + f. 1–8.* 16 O 1922.

Berry, E. W. Environmental interpretations of fossil plants. Pan-Am. Geol. **38:** 9–17. Au 1922.

Berry, E. W. A possible explanation of upper Eocene climates. Proc. Am. Phil. Soc. **61:** 1–14. S 1922.

Contains frequent references to the fossil flora.

Berry, E. W. *Sagenopteris*, a Mesozoic representative of the Hydropteraceae. Bot. Gaz. **74:** 329–331. *f. 1.* 23 N 1922.

Berry, E. W. Tertiary fossil plants from the republic of Haiti. Proc. U. S. Nat. Mus. **62^{14}:** 1–10. *pl. 1 + f. 1, 2.* 1922.

Includes 7 new species.

Berry, E. W. Additions to the flora of the Wilcox group. U. S. Geol. Surv. Prof. Paper 131: 1–21. *pl. 1–18.* 27 Jl 1922.

Includes *Calatoloides* and *Pterobalanus*, gen. nov., and 12 new species.

Black, O. F., & Kelly, J. W. Examination of the fruit of *Sanicula carnerosana* Trelease. Am. Jour. Pharm. **94:** 477–479. Jl 1922.

Blake, S. F. New Asteraceae from Utah and Nevada. Proc. Biol. Soc. Washington **35:** 173–178. 17 O 1922.

Species of *Aplopappus* (1), *Aster* (1), *Bahia* (1), and *Ptiloria* (1), with subspecies of other genera.

Blake, S. F. Key to the genus *Diplostephium*, with descriptions of new species. Contrib. U. S. Nat. Herb. **24:** 65–86. *pl. 21–28.* 1922.

Includes 13 new species from South America.

Blake, S. F. Two new species of Moraceae from South America. Proc. Biol. Soc. Washington **35:** 179, 180. 17 O 1922.

Brosimum columbianum from Colombia and *Brosimiopsis diandra* from Brazil.

Blake, S. F. Native names and uses of some plants of eastern Guatemala and Honduras. Contrib. U. S. Nat. Herb. **24:** 87–100. *pl. 29–33.* 1922.

Blake, S. F. New plants from South and Central America collected by Wilson Poponoe. Proc. Biol. Soc. Washington **35:** 117–124. 17 O 1922.

Species of *Tibouchina* (1), *Centronia* (1), *Gaultheria* (1), *Disterigma* (2), *Macleania* (3), and *Citharexylum* (1).

Blake, S. F. Two new species of letterwood (*Piratinera*). Jour. Washington Acad. Sci. **12:** 391–399. *f. 1.* 19 O 1922.

Both from Surinam.

Blake, S. F. New South American Asteraceae collected by E. W. D. Holway. Bot. Gaz. **74:** 414–430. *pl. 19.* 21 D 1922.

Includes *Monopholis* gen. nov. and 16 new species in various genera.

Blakeslee, A. F., Belling, J., & Harris, J. A. The probability established by a culture of given size that a mating is capable of producing only dominant individuals. Am. Nat. **56:** 458–461. O 1922.

Blomquist, H. L. Dormancy in seeds of persimmon. Jour. Elisha Mitchell Soc. **38:** 14. S 1922.

Bonar, L. The life history of *Rosellinia Caryae* sp. nov. causing a hickory canker and disease. Phytopathology **12:** 381–385. *f. 1–3.* 11 S 1922.

Dothichiza Caryae sp. nov., imperfect stage.

Bonns, W. W. A preliminary study of *Claviceps purpurea* in culture. Am. Jour. Bot. **9:** 339–353. *pl. 16–21.* 30 Au 1922.

Boshnakian, S. The genetics of squareheadedness and of density in wheat, and the relation of these to other characters. Cornell Univ. Agr. Exp. Sta. Mem. **53:** 801–882. *pl. 67, 68 + f. 78–85.* My 1922.

Boyer, C. S. New and rare species of Diatomaceae. Contrib. Biol. & Micr. Sect. Acad. Nat. Sci. Philadelphia **1:** 1–17. *pl. 1–4.* 15 Jl 1922.

Includes 32 new species.

Boynton, K. R. *Anoda hastata.* Addisonia **7:** 27, 28. *pl. 238.* 25 S 1922.

Brainerd, E. Violets of North America. Vermont Agr. Exp. Sta. Bull. 224: 1–172. *f. 1–75.* D 1921.

Breckenridge, L. P. *Asplenium ebenoides* a station in North Carolina. Am. Fern Jour. **12:** 64, 65. 11 S 1922.

Briggs, G. Leguminous crops for Guam. Guam Agr. Exp. Sta. Bull. 4: 1–29. *pl. 1–14.* Au 1922.

Briggs, G. The sorghums in Guam. Guam Agr. Exp. Sta. Bull. 3: 1–28. *pl. 1–9.* 4 N 1922.

Britton, E. G. On some mosses from the Blue Mountain of Cuba. Bryologist **25:** 89, 90. 7 N 1922.

Britton, E. G. Wild flowers needing protection. 14. Great laurel or rose bay (*Rhododendron maximum* L.). Jour. New York Bot. Gard. **23:** 137, 138. *pl. 277.* O 1922.

Britton, N. L. *Crotalaria retusa.* Addisonia **7:** 47. *pl. 248.* 4 D 1922.

Britton, N. L. *Polystachya minuta.* Addisonia **7:** 19. *pl. 234.* 25 S 1922.

Britton, N. L. *Xylophyllus epiphyllanthus.* Addisonia **7:** 31. *pl. 240.* Je 1922.

Britton, N. L., & Rose, J. N. The Cactaceae, vol. 3. pp. 1–255. *pl. 1–24 + f. 1–250.* Washington, D. C. 12 O 1922.
Includes 19 new genera and 35 new species.

Britton, N. L., & Rose, J. N. Two new genera of Cactaceae. Bull. Torrey Club **49:** 251, 252. 31 Au 1922.
Thelocactus and *Neolloydia*, gen. nov.,

Britton, N. L., & Wilson, P. Notes on plants collected by Mr. Bucher on Pico Turquino, Cuba. Jour. New York Bot. Gard. **23:** 91–94. Jl 1922.
Includes *Walleniella*, gen. nov., and new species in *Micromeria* (1), *Walleniella* (1), and *Xolisma* (1).

Brown, H. P. Trees of New York state, native and naturalized. New York State Coll. For. Bull. 21: 1–401. F 1921.
Profusely illustrated, with map and keys to the species.

Vol. 50 No. 5

BULLETIN

OF THE

TORREY BOTANICAL CLUB

MAY, 1923

Studies in the genus Lupinus—VIII. Lupinus nanus

CHARLES PIPER SMITH

(WITH SIX TEXT FIGURES)

The single species treated herein is the largest-flowered species of the *Micranthi*, the specific name applying to the stature of the plant, in its reduced forms, and not at all to the size of the flowers.

1a. LUPINUS NANUS Dougl.; Benth. Trans. Hort. Soc. Lond. II. 1: 409. 1835. [FIG. 79.]

Lupinus affinis Agardh, Syn. Gen. Lup. 20. 1835.

Annual, erect, 20–60 cm tall, simple or branched at the base, more or less villous and minutely spreading- or appressed-pubescent; leaves well scattered, or crowded by the development of axillary clusters; petioles slender, 4–8 cm. long; stipules subulate, 4–8 mm. long; leaflets five to seven, linear to spatulate, acute to rounded at the apex, 15–30 mm. long and 3–10 mm. wide (rarely 30–45 × 10–16 mm.); peduncles 4–8 cm. long, scarcely surpassing the foliage; racemes 6–20 cm. long, loosely flowered; flowers whorled, 10–16 mm. long; bracts deciduous, linear-lanceolate; pedicels slender, 5–8 mm. long; calyx bracteolate, its upper lip bifid, 4–5 mm. long, lower lip usually two- or three-toothed, 5–8 mm. long; petals broad, rich blue except the banner-spot which is first white or yellow, changing to violet, banner suborbicular, 11–15 mm. wide, 10–14 mm. long, often emarginate at apex, much reflexed, wings mostly concealing the keel, which is slender, usually not much curved, ciliate on the upper edges of the slender apex; pods appressed-pubescent, 20–35 mm. long, 4–6 mm. wide, ovules usually four to eight (rarely eight to twelve); seeds 2–3 mm. long, usually well marked

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[The BULLETIN for April (50: 133–158. *pl.* 5–7) was issued April 7, 1923.]

with brown or dark gray mottling;* tap root slender and much shorter than the stems.

Like *Lupinus sparsiflorus* Benth., this is a composite species exhibiting conspicuous and often confusing variations, apt to be misunderstood and treated as "new species." Its resemblance to *L. sparsiflorus* was noted by Bentham, who characterized the latter as:

> Flores iis *L. nani* subsimiles, omnes alterni v. rarius ; inc inde aproximati.

Should the opposing characters of flowers verticillate versus flowers non-verticillate at any time fail, the two species may be easily separated by the decided difference in the ciliation of the keel. Apparently their ranges do not overlap, unless, perhaps, in Ventura County.

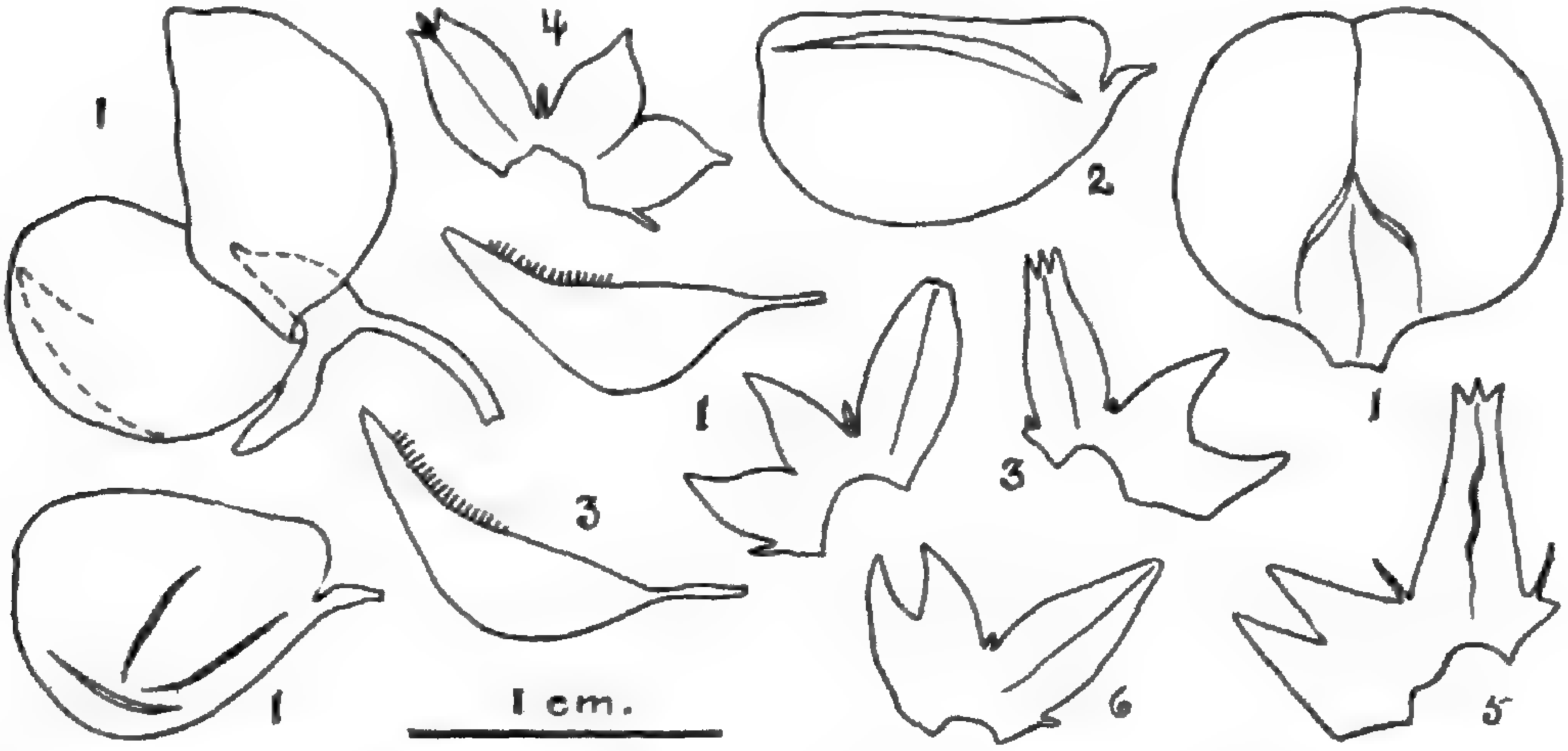

FIG. 79. LUPINUS NANUS Douglas. 1. *C. P. Smith 1170*, Pacific Grove (CPS); 2. *E. Hoisholt 104* (CPS); 3. *C. P. Smith 3369*, Olema (CPS); 4. *C. P. Smith 1384* (CPS); 5. *A. A. Heller*, April, 1902, Santa Rosa (B); 6. *C. P. Smith 3276* (CPS).

Though Bentham's original characterization of *L. nanus* is brief, he has given enough description to make recognition of the typical form a reasonable possibility. Extracts from his description follows:

> Annuus humilis pilosiusculus, caulibus decumbentibus parum ramosus . . . foliolis 5–7 spathulatis . . . floribus subverticillatis . .

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* At Felton, Santa Cruz County, a peculiar strain was found in which the seed varied from pale bluish-white or flesh-colored, unmarked, through various patterns and shades to a practically solid black, the color or pattern being quite constant for each individual plant.

labio superiore bifido inferiore longiore integro . . . flowers about the size of those of the annual lupin, but more elegant from their number and variagated colours.

Agardh's monograph accounts for *L. nanus*, but he evidently did not have access to Bentham's description, for he credited Swartz as authority for his cited reference. His description (Syn. Gen. Lup. 11. 1835) is more comprehensive than Bentham's but is based upon specimens seen in Lindley's herbarium. He included the species in his "Tribe D—*Angustifolii.*" Extracts from this treatment follow:

> *L. nanus* Dougl. mscr. Benth. in Hort. Trans. n.S.v.1. p. 409 t. 14 f. 2 (fide Sw.) Sweet. Britt. Flow. Gard. 2 ser. fol. 257. . . . caulis . . . patenter pilosus . . . foliola 7-nata lanceolato-linearia, extus paululum latiora . . . utrinque pilis patentibus obsito . . . verticillis sub- 5-floris, distantibus . . . calyx ebracteolatus . . . labio superiore subbipartito inferiore emarginato . . . vexilli disco purpureo-punctato . . . leguminibus glabris. Hab. in California legit Douglas; Specimina e seminibus inde reportatis, in Horto Hortic. Society enata, vidi in collectione Lindleyi.

Included in his "Tribe G—*Nootkatenses,*" on page 20 of his monograph, Agardh presented his *L. affinis*. This he compared with *L. nootkatensis* and *L. perennis* and associated same with species not at all related to this or to each other. As explained in my last paper of this series, this Agardhian name has been applied by American botanists to a very distinct Californian species, to which I have had trouble in fitting Agardh's description. This should, however, be carefully compared with his own characterization of *L. nanus*, and for this purpose I quote liberally, as follows:

> 33. *L. affinis* nob. caule herbaceo patenter pilose, foliolis 7 obovatis basique utrinque pubescentibus . . . calycibus verticillatis bracteolatis . . . labio superiore profunde bifido, carina ciliata.
>
> ? L. Nootkatensis var. Hook. Fl. Bor. Amer. IV. p. 163. Bot. Mag. t 2136.
>
> Hab. in California, unde specimina a Douglasio reportata vidi in Herb. Lindleyi. (Ad Nootka et in Rocky Mountains, si synonyma allata huc pertinent).
>
> Caulis decumbens videtur et herbaceus. Foliola obovata . . . utrimque pubescentia . . . Racemus laxus. Flores verticillati. Corolla . . . coerulea, vexilli medio flavicante.

Careful comparison of these two descriptions gives me no satisfactory evidence that two distinct species are being treated. Bentham refers to the leaflets of *L. nanus* as "foliolis 5–7 spathulatis," and Dr. Jepson has annotated the University of California sheet of Heller's 6571, from near Monterey, thus: "Leaves like leaves in *L. nanus* type, but a trifle larger. W. L. J., Kew, 1906." The leaflets in this specimen are spatulate or nearly so. However, Miss Eastwood's photo marked, "*Lupinus nanus*, ex Herb. Benth.", shows slender plants with leaflets oblanceolate and linear-oblanceolate, thus agreeing with Agardh's characterization of *L. nanus* where he says, "foliola . . . lanceolato-linearis." Then Agardh attributed to his *L. affinis*, "foliolis 7 obovatis;" but Miss Eastwood's photos, which are marked "*Lupinus affinis* Agardh, ex Herb. Lindl.," plainly show plants of *L. nanus*, one collected by Douglas, with spatulate leaflets, and two, one each by Hartweg and Douglas, with linear oblanceolate leaflets. Further, my study of many sheets of more recent specimens, together with considerable field experience with these variations and also with even greater extremes, has convinced me that it is certainly impracticable, if not quite impossible, to maintain a distinction between *L. nanus* and *L. affinis*. I might also add that "caule . . . patenter pilose" and "foliolis . . . utrinque pubescentibus," said of *L. affinis*, apply to *L. nanus* and not to the *L. succulentus* Dougl., known, since Watson's time, as *L. affinis* Agardh.

Nevertheless *L. nanus*, as I understand it, includes a few recognizable varieties which will be indicated after citing a representative selection from the more than one hundred sheets I have referred to the species, *sensu strictiore*.

CALIFORNIA: Alameda County: Berkeley, April, 1898, *J. B. Davy* (UC.); Oakland, March, 1864, *W. H. Brewer 2775* (CA, UC); same, July, 1901, *H. A. Walker 662* (BP). Butte County: Chico, April, 1914, *A. A. Heller 11311* (CA, DS); De Sable, June, 1917, *Helen M. Edwards* (DS); Oroville, March, 1913, *A. A. Heller 10685* (CPS, DS). Calaveras County: Mokelumne Hill, *F. E. Blaisdell* (CA). Contra Costa County: Point Isabel, April, 1897, *J. B. Davy* (UC). Lake County: Lower Lake, May, 1902, *Agnes M. Bowman 255* (DS); Weldon Valley, April, 1902, *Agnes M. Bowman 222* (DS). Marin County: Ignacio, April, 1918, *L. R. Abrams 6896* (DS); Kentfield, May, 1912, *A. Eastwood 11* (CA); Lagunitas, April, 1918, *F. Grinnell, Jr.* (DS); Olema, April, 1886, *E. L. Greene* (UC 196349); Point Reyes, May, 1906, *A. Eastwood* (CA); Sausalito, June, 1912, *A.*

Eastwood (CA). Mendocino County: Handley's, May, 1903, *J. I. McMurphey 146* (DS); Ukiah Valley, April, 1918, *L. R. Abrams 6979* (DS). Monterey County: Carmel Highlands, March, 1921, *C. P. Smith 3238* (CPS); Carmel Valley, July, 1906, *E. A. McGregor 78* (DS); Los Burros trail, Santa Lucia Mountains, May, 1897, *A. Eastwood* (CA); Jolon, April, 1915, *A. Eastwood 4129* (CA); Pacific Grove, *I. Tidestrom* (UC); Salinas, May, 1921, *J. C. Menker 101* (CPS); Seaside, April, 1903, *A. A. Heller 6571* (B, BP, DS, UC). Napa County; Calistoga, April, 1903, *C. F. Baker 1990* (B, BP, CA, UC); same, *J. P. Tracy 1847* (UC 156988 and 156989); Oakville, April, 1893, *W. L. Jepson* (UC). San Benito County; San Juan, May, 1903, *A. D. E. Elmer 4668* (BP, CA, DS, UC). San Francisco County: Forest Hill, April, 1921, *Bertha Dold 102* (CPS); Ocean View, April, 1894, *W. R. Dudley* (DS); Presedio, April, 1902, *C. F. Baker 698* (BP, CA, UC); Sand Hills, May, 1903, *C. F. Baker 2996* (BP, CA, UC). San Luis Obispo County: Arroyo Grande, April, 1861, *W. H. Brewer 451* (CA, UC); Paso Robles, April, 1899, *J. H. Barber* (UC); same, May, 1903, *G. B. Grant* (B); Point Harford, April, 1902, *W. R. Dudley* (DS); San Simeon, Aug., 1885, *T. S. Brandegee* (CA). San Mateo County: Baden, May, 1899, *W. R. Dudley* (DS); Crystal Springs Lake, April, 1903, *C. F. Baker 471, 1928* (BP); Lake Merced, April, 1907, *A. A. Heller 8452* (B, DS); Montara, May, 1912, *W. A. Setchell* (UC); Pescadero, April, 1896, *W. R. Dudley* (DS); San Gregorio, April, 1902, *C. F. Baker 507* (BP, UC). Santa Barbara County: without locality, May, 1902, *A. D. E. Elmer 4142* (DS). Santa Clara County: Betabel, April, 1921, *C. P. Smith 3263* (CPS); Gilroy Hot Springs road, April, 1921, *Mrs. V. Dold 101* (CPS); Madrone, April, 1921, *C. P. Smith 3276, 3279* (CPS); Palo Alto, May, 1893, *I. Tidestrom* (UC); Stanford University, May, 1902, *C. F. Baker 844* (CA, UC). Santa Cruz County: Capitola, April, 1903, *C. F. Baker 1964* (BP, CA, UC); Felton, May, 1921, *Estella Hoisholt 104* (CPS); Santa Cruz, April, 1897, *W. A. Setchell* (BP, UC). Sonoma County: Bodega, July, 1905, *K. Brandegee* (UC); Bodega Point, June, 1915, *A. Eastwood 4842* (CA); Healdsburg, April, 1902, *A. A. Heller 5233* (B, BP, DS, UC); Petaluma, April, 1908, *C. P. Smith 1384* (CPS); Santa Rosa, April, 1921, *A. Eastwood 10332* (CA). Tulare County: Kaweah

River Basin, April, 1901, *R. Hopping 97* (BP). Tuolumne County: top of Table Mountain, above Rawhide, April, 1919, *R. S. Ferris 1494* (CA, DS).

Key to the varieties of Lupinus nanus

- Densely villous with many hairs 2–3 mm. long; flowers 14 mm. long, wings about 10 mm. wide, keel strongly arcuate; pods 6 mm. wide, ovules six to seven; seeds 4 mm. long, 3 mm. wide ..... *1b.* var. *perlasius.*
- Loosely villous or appressed pubescent, no hairs over 1.5 mm. long.
  - Seeds 4–5 mm. long; pods 7–9 mm. wide, 30–50 mm. long; largest leaflets 7–15 mm. wide, 25–50 mm. long.......................... *1c.* var. *carnosulus.*
  - Seeds 1.5–3.5 mm. long; pod 3–6 mm. wide.
    - Ovules usually eight to twelve; seeds 1.5–2 mm. long, pale flesh-colored, more or less obscurely marked; pods 3–4 mm. wide...... *1d.* var. *Menkerae.*
    - Ovules usually four to eight (rarely more); seeds 2–3.5 mm. long; pods 4–6 mm. wide.
      - Flowers 11–16 mm. long; keel usually not strongly arcuate..................... *1a. L. nanus.*
      - Flowers 6–10 mm. long; keel usually strongly arcuate.
        - Seeds flesh-colored, more or less obscurely marked with darker; banner usually wider than long, little reflexed, its apex barely 2 mm. from upper distal united corners of wing petals........................... *1e.* var. ***vallicola.***
        - Seeds gray, much mottled with brown; banner as long as wide, well reflexed, its apex more than 2 mm. from upper distal united corners of wing petals................. *1f.* var. *apricus.*

1b. **Lupinus nanus perlasius** var. nov. [FIG. 80.]

A planta typico differt pilis pandentibus longissimis, foliis congestis et seminibus grandioribus; foliolis novem ad undecim, 20–25 mm. longis, alis 9–10 mm. latis, carina arcuatissima; leguminibus 30–35 mm. longis, 6 mm. latis; seminibus sex vel septem, 4 mm. longis, 3 mm. latis, linea atra prominenteque.

Differing from the typical plant in the very long, spreading pubescence, many hairs being 3 mm. long, the congested foliage, and the larger seeds: leaflets nine to eleven, 20–25 mm. long by 3–4 mm. wide; flowers 14 mm. long, wings 9–10 mm. wide, keel strongly arcuate; pods 30–35 mm. long by 6 mm. wide, ovules six or seven; seeds 4 × 3 mm., with a prominent, dark, lateral line.

CALIFORNIA. Mariposa County: Mariposa–Coulterville road, April, 1883, *J. W. Congdon* (TYPE, G).

Known only from the type specimen, a rather startling variation, probably as rare and local as it is odd.

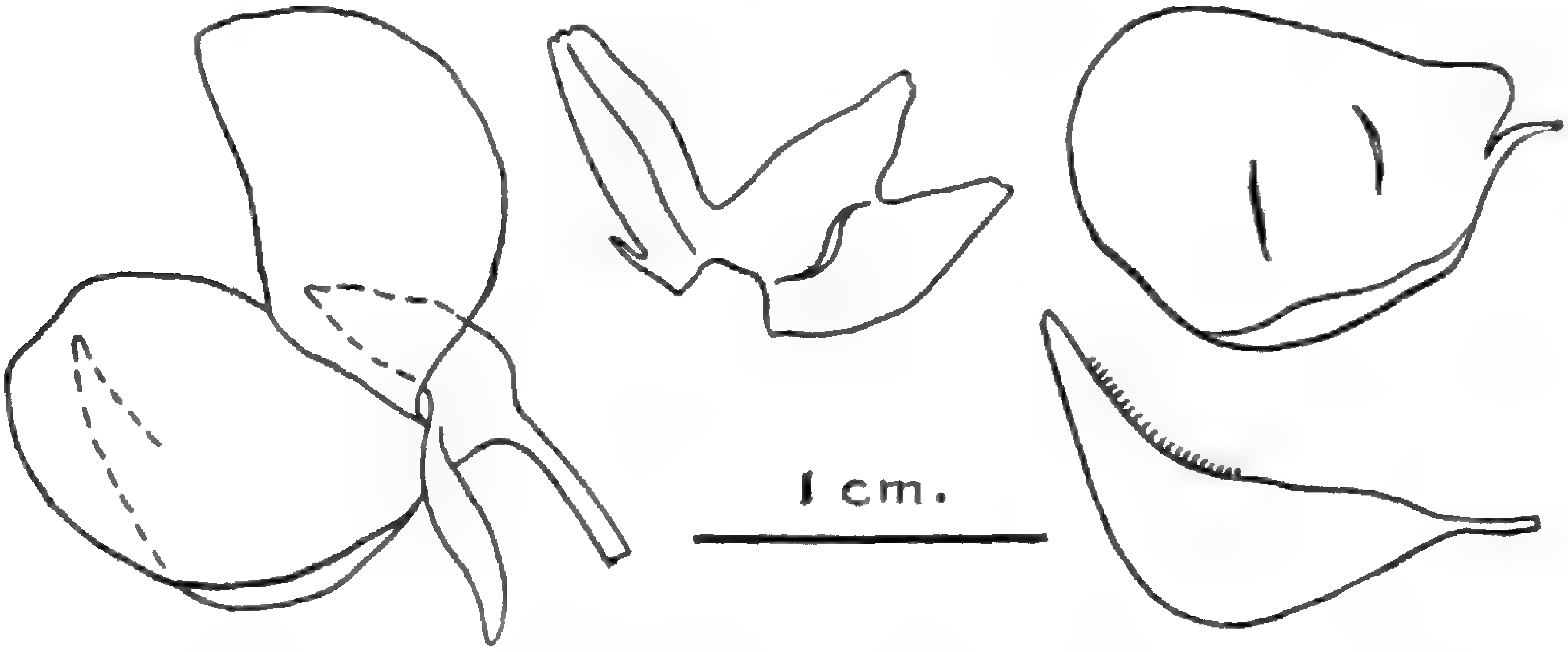

FIG. 80. LUPINUS NANUS PERLASIUS C. P. Smith. *J. W. Congdon*, April, 1883 (G).

1c. **Lupinus nanus carnosulus** (Greene) comb. nov. [FIG. 81.]

Lupinus carnosulus Greene, Bull. Cal. Acad. Sci. II. **6**: 144. 1886.
Lupinus affinis carnosulus (Greene) Jepson, Fl. West. Mid. Cal. 371. 1901.

Differing from the typical form in the size of the pods and seeds: largest leaflets 25-40 mm. long, 8-12 mm. wide; flowers 12-14 mm. long, keel not much curved; pods 30-50 mm. long 7-9 mm. ovules six to eight; seeds about 5 mm. long, 3-5 mm. wide, dark brown, heavily mottled.

Greene's original description is very brief but includes some interesting points. It is reproduced in full here:

> Annual, not slender, 1–2 feet high, somewhat succulent, finely pubescent, with appressed hairs: leaflets oblanceolate, an inch long, obtuse, but with a small, recurved cusp: racemes loose: bracts equalling the calyx, the upper lip of which is deeply cleft: corolla 5 lines long, deep blue throughout, keel naked: pods when young strongly villous-hirsute.
>
> Near the village of Olema, Marin County, April, 1886.
>
> Plant with the habit of large stages of *L. nanus*, but very distinct, wanting the variegated or changeable petals and villous-edged keel of that species; the herbage fleshy as in *L. affinis*.

The University of California has a sheet labelled, "*L. carnosulus* Greene, Olema, Marin County, April, 1886, E. L. Greene." This should therefore be a type-duplicate, if not the actual type; but some of the banners show a yellow center and white apex, and the keel petals are actually ciliate as in *L. nanus*, although the ciliated edges are more or less curved inward so as to make the ciliation less conspicuous than usual. I could easily pass this specimen as a large phase of *L. nanus* without an inclination to seek even a varietal name for it. However, the California Academy has a sheet labelled the same as the above, except as to specific locality, which is given as "Point Reyes." This is a more marked variation from typical *L. nanus*, and agrees with certain San Mateo County specimens also identified by Greene as *L. carnosulus*. As this form is what has been accepted by others under Greene's name, I consider it wiser to suggest no change of name here, except to place the plant where it belongs, as a variety of *L. nanus*. I have visited several of the localities where the variety has been found by others, both at flowering and fruiting season, and find the size of pods and seeds the only reliable characters for satisfactory identification. Miss Harriet L. Walker, in May, 1913, and myself, in May, 1921, visited Olema and vicinity seeking fruiting specimens and information concerning *L. carnosulus*. We each found *L. nanus, sensu stricto*, abundant and in full bloom, but no evidence of the large-fruited variety. However, Greene also took a plant at Olema, 16 April, 1886, which he labelled, "*L. nanus*" (UC 196349). I have seen no specimens with "naked keel."

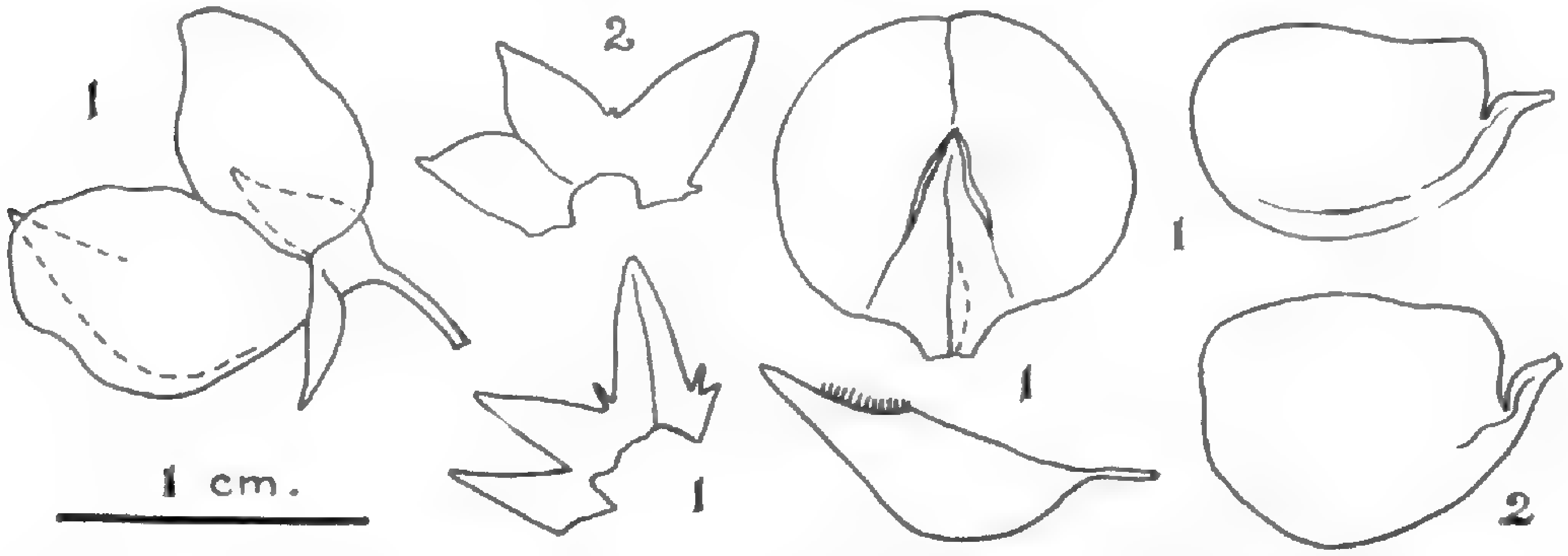

FIG. 81. LUPINUS NANUS CARNOSULUS (Greene) C. P. Smith. 1. *C. P. Smith 3290*, California (CPS); 2. *J. C. Nelson 3661*, Oregon (CPS).

CALIFORNIA. Contra Costa County: Oakland Hills, near tunnel, May, 1922, *C. P. Smith 3531* (CPS). Marin County: Point Reyes, April, 1886, *E. L. Greene* (CA). San Mateo County: Burlingame, May, 1895, *A. Eastwood* (CA); Crystal Springs Lake, April, 1896, *A. Eastwood* (UC); same, April

1902, *C. F. Baker 473* (BP, US) and *1728* (CA); LaHonda road, near summit, May, 1900, *W. R. Dudley* (CPS); Portola, April, 1903, *A. D. E. Elmer 5021* (CA, UC, US); San Mateo Canyon, April, 1921, *C. P. Smith 3290, 3292, 3293* (CPS); San Mateo Creek, April, 1895, *J. B. Davy 1087* (UC); San Mateo Ravine, April, 1894, *W. R. Dudley* (DS). Santa Clara County: Los Gatos, April, *T. S. Brandegee* (CA); Los Gatos foothills, April, 1904, *A. A. Heller 7298* (B, UC, US); Los Gatos Canyon, April 1894, *W. R. Dudley* (CPS); same, April, 1921, *C. P. Smith 3320, 3323, 3324* (CPS) and May, 1921, *C. P. Smith 3386* (CPS); near Stanford University, 1904, *W. R. Dudley* (CPS, DS).

OREGON. Benton County: near Corvallis, May, 1921, *J. C. Nelson 3661* (CPS); Lewisburg, July, 1922, *C. P. Smith 3568* (CPS). Douglas County: Riddle, May, 1922, *M. W. Gorman 5645* (CPS); Sutherlin, June, 1916, *M. E. Peck 5328* (WLU); Umpqua Valley, *T. Howell* (DS). Linn County: Eugene, May, 1920, *R. V. Bradshaw 1486* (CPS); same, May, 1921, *R. V. Bradshaw 2049* (CPS); same, April, 1922, *F. L. Wynd 921* (CPS). Marion County: Salem, May, 1911, *M. E. Peck 5454* (WLU).

1d. **Lupinus nanus Menkerae** var. nov. [FIG. 82.]

A *L. nano* typico differt leguminibus longis angustisque et seminibus 9–12; foliolis 10–15 mm. longis, floribus 10–12 mm. longis, vexillo emarginato, leguminibus 20–25 mm. longis, 3.5–4 mm. latis, seminibus 1.3–2 mm. longis pallido-carnosis paulo pallido-maculatis.

Differing from the typical form of the species in having the pods relatively long and narrow, and ovules nine to twelve; leaflets 10–15 mm. long, 2–3 mm. wide; flowers 10–12 mm. long, banner emarginate; pods 20–25 mm. long by 3.5–4 mm. wide, seeds 1.5–2 mm. long, pale flesh-colored, more or less spotted with a darker shade. While the color of the petals in the dried plants would pass as blue, except for the purple center of the banner, fresh plants sent me had pale lilac petals which turned decidedly bluish in the drying.

CALIFORNIA. Kern County: Bakersfield, April, 1896, *J. B. Davy 1707, 1925,* and *1930* (UC); same, April, 1905, *A. A. Heller 7588* (TYPE, B; type-duplicates, CPS, DS, UC); same, April, 1917, *A. Eastwood* (CA); same, April, 1922, *J. C.*

Menker & Edith Menker Smith 117 (CPS); Buena Vista hills, April, 1893, *A. Eastwood* (CA); Caliente, May, 1911, *K. Brandegee* (UC); Rosedale, March, 1900, *G. D. Abrams* (BP).

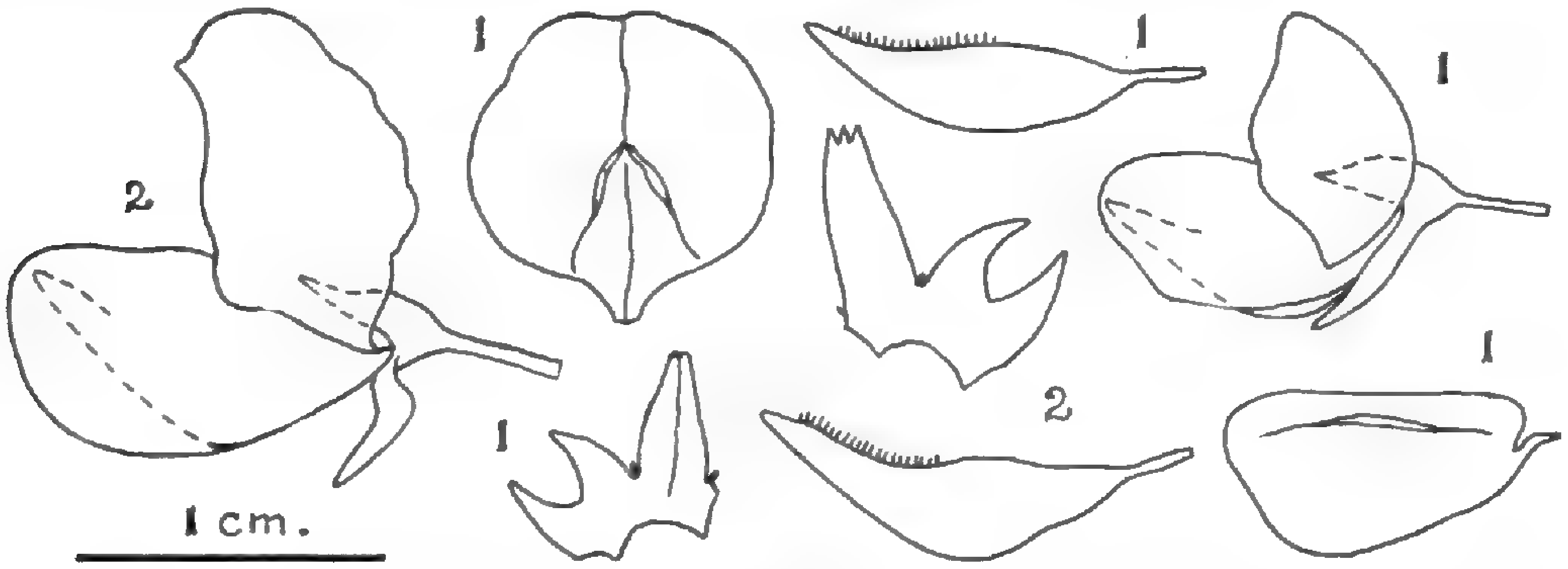

FIG. 82. LUPINUS NANUS MENKERAE C. P. Smith. 1. *A. A. Heller 7588* (B). 2. *A. A. Heller 7588* (CPS).

Heller (Muhlenbergia **2:** 63. 1905) recorded his observation that "this is not typical *nanus*, the leaves being narrower and the flowers smaller," but made no mention of the marked differences in the pods and seeds.

1e. **Lupinus nanus vallicola** (Heller) comb. nov. [FIG. 83.]

Lupinus persistens Heller, Muhlenbergia **2:** 62. 1905.
Lipinus vallicola Heller, ibid. **4:** 40. 1908.

Differs mainly from typical *L. nanus* in the smaller size of the flowers and the curvature of the keel; leaflets linear-oblanceolate, 10–25 mm. long, 2–4 mm. wide; flowers 6–10 mm. long, banner usually wider than long, its apex little separated from the united apices of the very wide wing petals, keel usually much curved; pods 15–25 mm. long, 4–5 mm. wide, ovules five to eight; seeds about 2.5 mm. long, pale flesh-colored, more or less mottled with a darker shade, often with a lateral line.

CALIFORNIA. Amador County: Jackson, June, 1904, *E. Mulliken 104* (B, BP, DS, UC); Sutter Creek, May, 1918, *Ann Wood* (DS). Butte County: Clear Creek—Paradise grade, May, 1902, *Heller & Brown 5530* (BP, DS); same, May, 1914, *A. A. Heller 11378* (CA, DS, UC, UCX); Cherokee Mine, April, 1919, *A. A. Heller 13105* (CA, UCX); Oroville—Forbestown road, May, 1915, *A. A. Heller 11890* (B, CA, DS, UCX). Calaveras County: Copperopolis, May, 1895, *J. B. Davy 1368* (UC). Eldorado County: Fyffe, July, 1908, *K. Brandegee* (UC); Pilot Hill, May, 1909, and April, 1915, *K. Brandegee*

(UC); near Tallac, June, 1893, *W. R. Dudley* (DS). Fresno County: Squaw Valley road, April, 1921, *P. B. Kennedy* (UCX). Kern County: Greenhorn Range, June, 1904, *Hall & Babcock 5040* (UC). Mariposa County: Crockers, May, 1895, *W. C. Blasdale* (UC); Hetch Hetchy Valley, July, 1902, *Hall & Babcock 3387* (UC); Wawona, June, 1911, *H. M. Hall 9007* (UC); Yosemite Valley, July, 1919, *S. S. Towne & E. P. Chase 4* (CPS). Nevada County: Penn Valley, May, 1919, *A. A. Heller 13185* (CA, UCX). Placer County: Colfax, May, 1907, *C. P. Smith 1280* (CPS); same, June, 1912, *A. Eastwood 495* (CA, CPS). Plumas County: Quincy, June, 1913, *A. A. Heller 10865* (CPS, DS, UCX); same, July, 1921, *C. P. Smith 3426* (CPS). Sacramento County: Folsom, April, 1916, *A. A. Heller 12316* (CA, DS, UCX); near Sacramento, April, 1918, *Edna Hannibal* (DS). Santa Clara County; below Wright, June, 1921, *C. P. Smith 3404* (CPS). Shasta County: Redding, May, 1905, *A. A. Heller 7850* (B, UC); Castella, July, 1912, *A. Eastwood 1396* (CA, CPS); McCloud River, May, 1918, *A. A. Heller* (CA, UCX); Stillwater, April, 1900, *M. S. Baker* (UC). Sierra County: Cedar Glen, May, 1920, *V. Jones* (CA). Sutter County: Marysville, March, 1905, *A. A. Heller 7555* (B, UC); Tuolumne County: Hetch Hetchy, June, 1889, *Chesnut & Drew* (UC); Middle Fork Tuolumne River, June, 1911, *H. M. Hall 8910* (UC). Yuba County: Los Virgils, May, 1921, *A. Eastwood 10552* (CA, CPS).

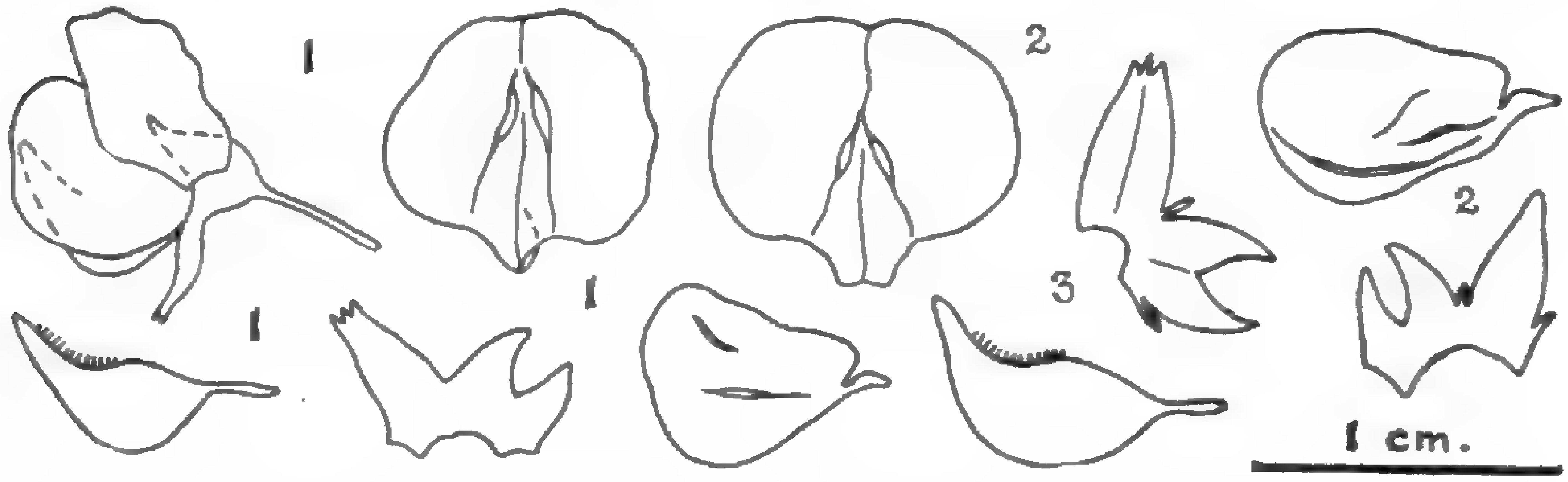

FIG. 83. LUPINUS NANUS VALLICOLA (Heller) C. P. Smith. 1. *A. A. Heller 7850*, Redding (B); 2. *A. A. Heller 10865*, Quincy (CPS); 3. *C. P. Smith 1280*, Colfax (CPS).

The above citations show that this is preeminently a form of the Sierra foothills, having been taken in at least seventeen counties, from Shasta to Kern, as far up in the mountains as Tallac, as low down in the valley as Marysville and Sacramento.

The one station in the coast region, near Wright, is along the railroad where coarse rock had been dumped, and it is evident that seed was brought in some way from the region of its natural range.

As the original descriptions of this and the next are readily available, they will not be reproduced here.

1f. **Lupinus nanus apricus** (Greene) comb. nov. [FIG. 84.]

Lupinus apricus Greene, Leaflets **2:** 67. 1910.

Lupinus vallicola apricus (Greene) C. P. Smith, Muhlenbergia **6:** 135. 1911.

Lupinus hirsutulus Greene, Leaflets **2:** 152. 1911.

Very much like var. *vallicola*, but the apex of the orbicular banner well separated from the united apices of the wing petals; leaflets 15–40 mm. long, 2–5 mm. wide; pods 15–25 mm. long, 4 mm. wide, ovules six to eight; seeds about 2.5 × 2 mm., gray, much mottled with brown, very much like a common type of seed of the typical, larger-flowered plant.

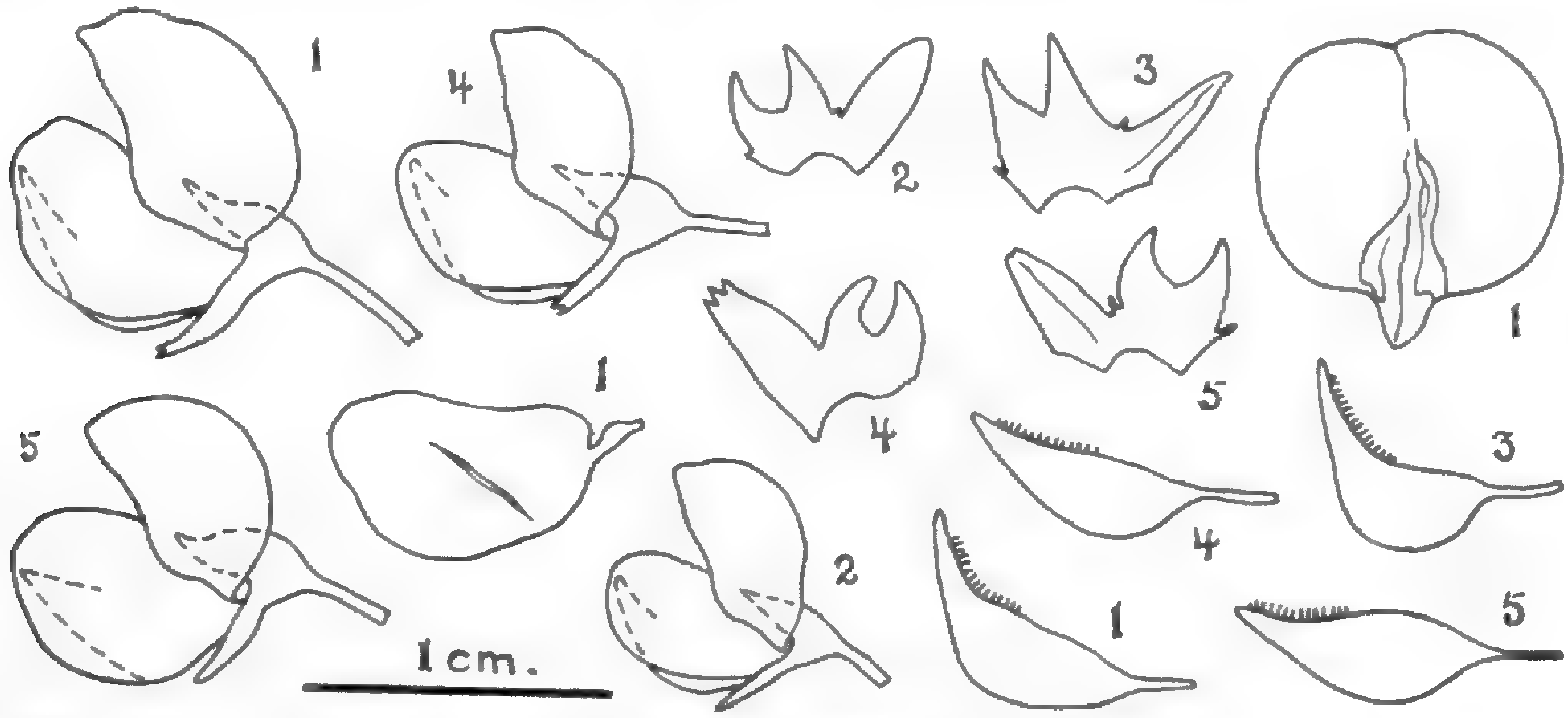

FIG. 84. LUPINUS NANUS APRICUS (Greene) C. P. Smith. 1 *C. P. Smith 1374*, Stanford University (CPS); 2. *C. P. Smith 1395*, Stanford University (CPS); 3. *L. R. Abrams 6473*, Monterey County (DS); 4. *A. A. Heller 10021*, Oregon (CPS); 5. *J. Macoun 78891*, Vancouver Island (B).

CALIFORNIA. Lake County: Burns Valley, April, 1902, *Agnes M. Bowman 154* (DS); Clear Lake, June, 1922, *E. A. McGregor* (CPS); Lakeport, May, 1903, *C. F. Baker 2960* (BP); same, May, 1917, *G. Bentley* (DS); Sulphur Banks, April, 1902, *Agnes M. Bowman 36* and *204* (DS). Mendocino County: Ukiah, June, 1913, *A. Eastwood* (CPS); near Ukiah, April, 1918, *L. R. Abrams 6991* and *7013* (DS). Monterey County: Kings City—Jolon grade, June, 1917, *L. R. Abrams*

6473 (DS); San Antonio Creek, May, 1895, *W. R. Dudley* (DS); Santa Lucia Mountains, April, 1908, *E. G. Dudley* (DS); Tassahara Hot Springs, June, 1901, *A. D. E. Elmer 3272* (DS). San Mateo County: Redwood City hills, April, 1921, *C. P. Smith 3289* (CPS); Woodside, hills north, *C. P. Smith 3498* (CPS); near Stanford University, April, 1908, *C. P. Smith 1374* (CPS, DS). Santa Clara County: Campbell, April, 1920, *H. A. Borthwick* (DS); Call-of-the-Wild, April, 1921, *C. P. Smith 3315* and *3316* (CPS); Gilroy, April, 1921, *C. P. Smith 3254* and *3255* (CPS); Los Gatos, April, 1897, *F. T. Bioletti* (UC); same, April, 1904, *A. A. Heller 7294a* (B, UC); Monte Bello Ridge, April, 1921, *C. P. Smith 3334* (CPS); Saratoga, March, 1921, *Edith M. Smith 101* (CPS); Stanford University, April, 1902, *C. F. Baker 610* (B, BP, CA, UC) and *644* (BP, CA, UC); same, April, 1902, *L. R. Abrams 2372* (DS); same, March, 1919, *Roxana S. Ferris 1467* (CPS). Shasta County: Anderson, April, 1913, *L. E. Smith 142* (CA, CPS). Sonoma County: Santa Rosa hills, March, 1902, *Heller & Brown 5115* (BP, DS); Santa Rosa, May, 1920, *G. H. Mallory* (DS). Trinity County: Weaverville, 1914, *H. S. Yates 292* (UC); same, April, 1915, *Anna A. Junkans* (CA).

OREGON. Curry County: Snow Camp, July, 1916, *J. H. Thompson 35* (DS). Josephine County: Gold Hill, May, 1916, *S. G. Jewett* (WLU); Grants Pass, May, 1910, *A. A. Heller 10021* (CA, CPS, DS, UCX); same, May, 1912, *H. S. Prescott* (CPS); same, April, 1913, *Lois Dale* (DS).

BRITISH COLUMBIA. Vancouver Island: Victoria, uplands, May, 1917, *W. B. Anderson* (PBC); Esquimault, May, 1908, *J. Maccun 78891* (B).

Like var. *carnosulus*, var. *apricus* was described by Greene as having a "naked" keel, whereas both are constantly ciliate as in *L. nanus.* For some years I have tried to accept var. *vallicola* as a good species; but I have repeatedly failed to find characters dependable for an accurate separation of the two. Too many puzzling intermediates have been secured, and some of these will probably continue to defy identification even by means of the varietal classification that I am offering herewith. Several additional varieties could be indicated, but not, as I now see it, to any good purpose, especially if based primarily upon pubescence. Thus *L. hirsutulus* Greene has at no time gained my respect, and I am now unable to separate it from var. *apricus*, although it does seem to lean strongly toward *L. bicolor*, as the usual determination indicates. Many of my numbers of var. *apricus* have not been cited above. It is abundant in many localities of the foothills of the eastern edge of the Santa Cruz Mountains, from about San Carlos to Gilroy, apparently with a greatly interrupted or spasmodic distribution elsewhere.

The abbreviations used herein in the citation of specimens may be identified by reference to the following list:

B, Brooklyn Botanic Garden.
BP, C. F. Baker Herbarium, Pomona College, Claremont.
CA, California Academy of Science.
CPS, herbarium of the writer.
DS, Dudley Herbarium, Stanford University.
G, Gray Herbarium, Harvard University.
PBC, Provincial Museum, Victoria, British Columbia.
UC, Department of Botany, University of California.
UCX, Division of Agronomy, University of California Experiment Station.
US, United States National Herbarium.
WLU, Willamette University, Salem, Oregon.

SAN JOSE, CALIFORNIA

Tolypella longicoma in Cayuga Lake, New York

ROMYN HITCHCOCK

(WITH PLATE 8)

This species was originally described and named by A. Braun (1, p. 96) from specimens collected by Professor Lesquereux in swamps near Columbus, Ohio, in 1855. Allen (2) gives a translation of Braun's description with the comment: "I have been unable to obtain specimens of this species . . . I await its rediscovery." No later record of the species is to be found.

When collecting from the shore at the southeastern corner of Cayuga Lake, June, 26, 1921, I found a plant growing in tufts in the shoal water. On June 29, I collected the same plant from a boat in about four feet of water. The growth was abundant, covering the bottom in tufts about 15 cm. tall for square yards. The plants were fruiting finely in the upper whorls, the sporophydia and antheridia both being of a brilliant orange color. But as the fruiting was immature it seemed advisable to defer much collecting until a later day. This was unfortunate, for on July 11 the entire growth had disappeared. Only a few single plants could be found by selecting them from vigorous growths of *Chara*.

Such remarkably rapid growth, development and disintegration were not anticipated. However, Migula (3) states concerning plants of this genus: "They grow under favorable conditions remarkably fast and frequently reach in a few weeks their full size and development, whereupon they break up and disappear with the same quickness." As to *T. glomerata*, closely related to the Ithaca plant, he says that the spores ripen about the middle of April and that "immediately the plant breaks up and leaves no trace."

The next season, 1922, I began searching for the plant early in June but only on the 28th did I find a few single plants, brought up with charas, etc. Some of these showed protonemal growths with germinated spores attached. Repeated visits to the location during July and August failed to disclose any noticeable growth of the plant where it was so abundant the year before. Perhaps the excessive early rainfall, which raised the water level and carried more sediment than usual, may account for this.

The plant was first entered in my notes as *T. comosa* Allen, which was found in Seneca Lake in August, 1882. But *T. comosa* has considerably larger spores and differs in other minor respects. On further study there seems no doubt that the plant is most nearly related to *T. longicoma* and that it can not be specifically separated therefrom. The Cayuga Lake plant is smaller and somewhat incrusted, the spores are black with seven or eight striae (not brown as described by Braun), and they ripen in July; otherwise there is no difference.

The general habit of growth is shown in FIG. 1, which represents an entire young plant from the node above the protonema. Four conspicuous stem-branches have developed from the node, and these bear fruiting heads at the upper verticils. The close fruiting of the upper verticils of well-grown plants is shown in FIG. 5 and, somewhat enlarged, in FIG. 4.

The sterile leaves which arise in verticils from the lower stem nodes are simple, very long, of uniform diameter throughout (not "slightly attenuate" as Braun observed), about 0.2 mm. in diameter, and with blunt, rounded, and incurved ends. They are usually three-celled, with the terminal cell the longest, and may attain a length of 5 cm., thus exceeding the stem internode above.

The fertile leaves divide near the base but have only one leaflet-forming and fruiting node, bearing an antheridium between two sporophydia and normally three short leaflets, two lateral and one dorsal, with a relatively long leaf terminal (FIGS. 2, 3). The long terminals and leaflets are three-celled, not attenuate and are blunt-rounded. The first leaf-segment may be very short, 1–2 mm. or less, or considerably longer, and the terminal extension may be 2–3 cm. long or more. This is the typical form of fruiting leaves, but in the close-fruiting heads they are naturally quite small and, as Braun remarks, "the lateral leaflets either do not develop on the inner leaves of the smaller fertile heads, or, at least, are so dwarfed as to be indistinguishable."

The heads are made up of verticils of fruiting leaves at the ends of very short stem branches within the upper large stem verticils. Braun writes: "fertile verticils bunched; bunches complicated by axilliary shoots." Doubtless the "axilliary shoots" are the stem branches mentioned and this reference to the structure of the heads tends to confirm the species relation. The stem branches may be 2–5 mm. in length or less, with whorls of six or seven fertile leaves having very short basal segments.

Antheridia are usually sessile but occasionally are borne on pedicels equaling their own diameter. Sporophydia are sometimes very short stiped—my impression is that this applies only to those which develop in the fundus of a verticil.

As the spores ripen for fertilization the neck-cells of the sporostegium become greatly enlarged (see FIGS. 6, 7). Such conspicuous enlargement is not common in the family but is notable in *T. glomerata* and in *Nitella opaca*, which also is found about Ithaca. I have not seen the processes of fertilization but I have seen the opening of antheridia and the swimming sperms. Now, with plants of this family generally, mature fruits may be found in the lower verticils, while the earlier stages may be seen above. Therefore it is remarkable, if the number of specimens I have collected during two seasons is considered, that I have not found on a growing plant a single mature fruit, such as is required to determine the markings and color of the mature spore. Possibly my collection at the time when sporophydia and antheridia were numerous happened to be made a few days before any fruit had matured on any of the plants. In less than ten days thereafter the plants had utterly disappeared. There is here a gap in my record much to be deplored.

In other species the cells of the sporostegium become active after fertilization in forming a lignified, colored membrane around the spore, which may have various thickenings or spiral striae. I have not been able to discover any indication of the development of such a spore membrane in any growing plant collected. By careful manipulation the sporostegium envelope may be separated from the young spore which is then seen to have a thin, hyaline coat well filled with starch. One such spore is shown in FIG. 7. Many such dissections have failed to reveal any indication of further membrane development.

Nevertheless, the usual lignified membrane forms, and perhaps cultures in glass would make it possible to follow the development of the spores after fertilization, although my own efforts in that direction have not succeeded. The only examples of mature spores I have found are two germinated spores on one of my herbarium sheets marked "protonemal growth and spore cases," June 26, 1921. These date back to the year before and were still connected with the protonemas and plants developed therefrom. They were removed and mounted for microscopical examination and are shown in FIG. 8.

The author's measurements of the Cayuga Lake plant may be compared with Braun's measurements of the Columbus plant as follows:—

	Author	Braun
Antheridia	0.37–0.44 mm.	0.36 mm.
Sporophydia		
Length	0.35–0.57 mm.	0.38–0.6 mm.
Width	0.4 mm.	0.42–0.44 mm.
Spores		
Length	0.3–0.38 mm.	0.36–0.4 mm.
Width	0.3–0.34 mm.	0.3–0.32 mm.
Crown		
Height	35 μ	
Width	85 μ	

ITHACA, NEW YORK

LITERATURE CITED

1. **Braun, A.** Fragmente einer Monographie der Characeen. Abhandl. Königl. Akad. Wiss. Berlin **1882**: 1–211. *pl.* 1–7. 1883.
2. **Allen, T. F.** Notes on the American species of *Tolypella.* Bull. Torrey Club **10**: 109–117. *pl. 37–42.* 1883.
3. **Migula, W.** Die Characeen. Rabenhorst's Kryptogamenflora **5.** 1900.

Explanation of plate 8

TOLYPELLA LONGICOMA A. BR.

FIG. 1. Plant, natural size.
FIG. 2. Fertile leaves.
FIG. 3. Fertile leaves.
FIG. 4. Enlarged verticils of fertile leaves.
FIG. 5. Fruiting heads.
FIG. 6. Sporophydia, neck-cells enlarged.
FIG. 7. Two sporophydia and dissected out young spore.
FIG. 8. Germinated spores (from dried specimen).

TOLYPELLA LONGICOMA A. BR.

Notes on Fabaceae—I

PER AXEL RYDBERG

HOMALOBUS Nutt.

For several years I have worked on genera of the Fabaceae for the North American Flora. Two parts containing the tribe Psoraleae have already been published, and the manuscript for the Indigoferae and a large part of the Galegeae is ready. My work has taken me to *Astragalus* and related genera. I have heard a rumor that M. E. Jones has been working on an illustrated revision of *Astragalus*, and I wish that this had been published so that I could have availed myself of it in my studies. It would perhaps have helped me to avoid some of the errors which are so likely to creep in.

There is little room for critical notes in the Flora, and yet notes of this character are necessary for a proper understanding of my disposition of genera and for a just appreciation of the amount of work that I have done on the group. It is my intention, therefore, to publish a series of preliminary notes in order to thresh out any unavoidable criticism, which might come from certain quarters, before my final monograph is published. If I should criticise any fellow botanist in this undertaking I do it in order to bring out the facts.

Just before the present paper was completed there appeared an article by J. F. Macbride, entitled: A revision of *Astragalus*, subgenus *Homalobus*, in the Rocky Mountains.* Now it may perhaps seem superfluous for me to go into details and publish another paper on the same subject so soon. So far as generic and specific limits are concerned, I do not think that either Macbride or Jones can ever agree with me. It surprises me, however, that so many of my species, even some that had been sneered at by Jones, have been accepted by Macbride. That he should have reduced some of my species to varieties I might have expected, since I do not see where to draw lines between species and varieties and prefer a binomial name to a trinomial

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* Contr. Gray Herb. II. **65**: 28–39. 1922.

for the sake of convenience. He has not treated me more harshly in this respect than he has others; for he has reduced to varieties or synonyms the species of other botanists, such as *Astragalus lingulatus* Sheld., *A. exiliflorus* A. Nels., *Homolobus caespitosus* Nutt., *H. canescens* Nutt., *H. brachycarpus* Nutt., *A. amphidoxus* Blankinship, *H. dispar* Nutt., *H. junceus* Nutt., *A. junciformis* A. Nels., *A. diversifolius* Gray, *A. strigosus* Coult. & Fish., *A. Palliseri* Gray, and *A. acerbus* Sheld. In this way he has reduced half of Nuttall's species, all of A. Nelson's and all but one of Sheldon's. Is such a reduction warranted?

I once criticised Brand for his work on the Polemoniaceae, because he did not try to find what the types really represented. May I not now have the right to criticise Macbride for the same laxities? In his paper on *Homalobus* he reduced my *H. microcarpus*, *H. proximus*, and *H. Salidae*, although he admitted that he had not seen the types; he reduced also my *H. Clementis*, *H. stipitatus* and *H. uniflorus*, without including the types among the specimens cited, thus implying that he did not have them before him. The same can be said about Sheldon's *Astragalus lingulatus* and *A. acerbus*. Except in the case of *A. lingulatus* the types of all these species are readily accessible to anyone who may wish to see them.

As I have not found it necessary to change essentially my grouping of the species from that published in my Flora of the Rocky Mountains, I shall keep the same groups as there. I shall also omit the keys except in cases where the species are from the Pacific coast. Keys would be superfluous, since my own are found in my Flora of the Rocky Mountains and since Macbride has given a good one in the paper cited above.

A. CAESPITOSI

1. HOMALOBUS CAESPITOSUS Nutt. This is the most common and best known of the group, and its nomenclature has not been much confused. Occasionally the leaves are two- or three-foliolate instead of simple. *H. canescens* Nutt. is only a more silvery form of the species. Gray, who merged *Homolobus* in *Astragalus*, recognized the identity of the two, retaining the specific name *caespitosus*, although there was an earlier

Astragalus caespitosus Pallas. On this account Sheldon substituted the name *A. spatulatus*. In the meantime O. Kuntze had transferred all species of *Astragalus* to *Tragacantha*. M. E. Jones* has made *A. caespitosus* a variety of *A. simplicifolius* (Nutt.) A. Gray, probably because he did not understand the latter species, which is discussed below. Macbride has followed Jones.

2. HOMALOBUS BRACHYCARPUS Nutt. Gray, Watson, Sheldon, Jones, and Macbride have regarded this as a synonym of *H. caespitosus*. Nuttall distinguished it by its shorter, broader and more abruptly acute pod and by its smaller size. I take it to be the same as the plant described and figured by Watson in King's Report under the name *Astragalus simplicifolius* Gray, although the leaves of Nuttall's specimens are narrower than those figured by Watson. Evidently Jones has followed Watson in his interpretation, for he has shown the close relationship between what he called *A. simplicifolius* and *A. caespitosus*, and afterwards went so far as to make the latter a variety of *A. simplicifolius*. The plant described and figured by Watson, however, is not the same as *Phaca simplicifolia* Nutt.; if it is not *H. brachycarpus* it is without a name. The duplicate of Nuttall's type of *H. brachycarpus* in the Torrey Herbarium strongly resembles Watson's plant but is somewhat taller and has narrower leaves. That in the Gray Herbarium is different and is exactly like the type of *H. canescens*; it does not agree with the description of *H. brachycarpus*. The following specimens belong to the latter:—

WYOMING: hills on the Platte, *Nuttall*; northwestern Wyoming, *Jones 68*; Big Horn Mountains, *Tweedy 136*; Laramie Plains, 1897, *Osterhout*; Fort Steele, *Tweedy 4193*; Pine Bluffs, *A. Nelson 2877*; Natrona, *A. Nelson 142*; Laramie, *A. Nelson 31, 7289*; Fort Bridger, *Lauderdale*.

UTAH: Unitah Mountains, *Goodding 1285*; Wasatch Mountains, *Watson 289*.

3. HOMALOBUS SIMPLICIFOLIUS (Nutt.) Rydb. There are several points in the original description of Nuttall's *Phaca simplicifolia* that do not fit Watson's plant, such as the following: "scapes 1–2-flowered, scarcely exserted;" "legumes glabrous,

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* Proc. Calif. Acad. II. **5**: 647. 1895.

coriaceous, sessile, somewhat triquetrous, pointed, scarcely longer than the calyx;" "flowers ochroleucous." In Watson's plant the scape is three- to seven flowered, usually as long as, or longer than, the leaves; the pod is decidedly flat; and the corolla is purple. All the characters given by Nuttall fit *A. exiliflcrus* A. Nelson, but I do not think that the two are identical. There is, however, a plant of southern Wyoming and northern Colorado that agrees fully with Nuttall's type. This resembles Nelson's species but is smaller and has shorter leaves. In this respect it approaches *H. brachycarpus*, being distinguished from that species by its narrower and more pungent leaves and by its shorter, unmottled, and rather turgid pod, thicker nearer the lower suture than the upper, hence Nuttall's expression, "somewhat triquetrous." Nuttall's specimen in the Gray Herbarium has leaves only, so that Watson had no opportunity to compare the pods. The following specimens belong to this species:—

WYOMING: Rocky Mountains, *Nuttall; Fremont;* Ham's Fork, *C. C. Curtis*; Green River, *Jones*; Hanna, *Payson & Payson 1694*.

COLORADO: Canon City, *Brandegee.*

4. HOMALOBUS EXILIFOLIUS (A. Nels.) Rydb. See notes under the preceding species. The following specimens belong here:—

WYOMING: Freezeout Hill, *Elias Nelson 4493*; Fort Steele, *Tweedy 4194*.

5. HOMALOBUS LINGULATUS (Sheld.) Rydb. This is known only from the original collection, and its description is much like that of the preceding species, the only essential difference being the glabrous calyx. The mature fruit is unknown. When the plant is better understood it may prove to be the same as *H. exilifolius*, in which case the species should bear Sheldon's specific name, which antedates Nelson's by five years.

6. HOMALOBUS UNIFLORUS Rydb. It is possible that this may represent an aberrant form of *H. brachycarpus*, i.e. *Astragalus simplicifolius*, as understood by Watson. The pod, however, is different, being lanceolate in outline, more tapering at the apex, 6–7 mm. long and 2–3 mm. wide. It is, therefore,

more like that of the true *H. simplicifolius*.* The following specimens may be cited:—

WYOMING: Evanston, *A. Nelson 2971* (flower); Carter, *M. E. Jones* (fruit).

B. TENELLI

7. HOMALOBUS TENELLUS (Pursh) Britton. The description of *Astragalus tenellus* Pursh, dating from 1814, was drawn (according to Pursh himself) from flowering specimens of the present species and the fruit of some other *Astragalus*, both of which had been collected by Lewis. When Pursh found that his description had been based on a mixture, he redescribed the flowering specimens, associating them with a fruiting plant collected by Bradbury on the Upper Missouri and giving the species the new name *Ervum multiflorum*, on account of its *Ervum*-like pods. A fragment of Bradbury's plant in the Torrey Herbarium is clearly identical with the flowering specimens collected by Lewis: hence there is no doubt that *Astragalus tenellus* (so far as the flowering specimens are concerned) and *Ervum multiflorum* are the same.

8. HOMALOBUS DISPAR Nutt. Nuttall first described this species in 1818 under the name *Orobus dispar*, from specimens that he collected at Fort Mandan. To those who consider *H. dispar* and *H. tenellus* identical, this note will be of no interest. It is here presented, however, for the benefit of those who are willing to admit their distinctness as species or varieties. Since Nuttall and Bradbury were members of the same expedition and often collected together, one might perhaps assume that *Orobus dispar* and *Ervum multiflorum* were the same. They are not. Nuttall's specimen in the Torrey Herbarium agrees with his description in having broader leaflets than *H. tenellus* and broader short-stipitate pods. Of *Phaca nigrescens* Hook., which was described in 1830 from specimens collected by Richardson, there is likewise a duplicate in the Torrey Herbarium. This belongs to *H. dispar*, while a specimen collected by Nuttall on the Platte River, which was named *Homalobus nigrescens* by him and *Astragalus multiflorus* by Hooker, is like *A. tenellus* Pursh. Macbride states correctly that "Nuttall's

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* See also Bull. Torrey Club **34:** 49. 1917.

specimen in the Gray Herbarium has narrowly linear leaflets and the stipe of even very immature pods is quite as long as the calyx." These statements do fit Nuttall's specimens of "*H. nigrescens*" in the Torrey Herbarium but not his description of *H. dispar*. The specimens in question were collected on the Missouri, but I do not know the date; there is no evidence that they came from Fort Mandan.

9. HOMALOBUS STIPITATUS Rydb. Although *H. tenellus* is much more common than *H. dispar*, the two species have nearly the same range; *H. stipitatus* is confined to the northeastern part of this range. All the specimens in the New York Botanical Garden Herbarium are cited under the original description and need not be repeated here.

10. HOMALOBUS STRIGULOSUS Rydb. Macbride has reduced this to *Astragalus tenellus* forma *strigulosus*. An additional specimen is here recorded:—

UTAH: Jugtown, *Jones 5400*.

11. **Homalobus Standleyi** sp. nov.

Astragalus tenellus var. *Clementis* Macbride, Contr. Gray Herb. II. **65:** 35 (in part). 1922.

A perennial, with a caespitose caudex; stems 2–3 dm. high, sparingly strigose; stipules deltoid, about 2 mm. long, connate; leaves 3–5 cm. long; leaflets nine to fifteen, elliptic or oblong, 5–10 mm. long, 2–3 mm. wide, glabrous above, strigose beneath; racemes lax, 4–7 cm. long, including the short peduncle; bracts lance-subulate, 1–2 mm. long; calyx strigose, the tube 2 mm. long, the teeth subulate, fully 1 mm. long; corolla white or tinged with purple, the keel purple-tipped; banner 6 mm. long, obovate, slightly retuse; wings 5 mm. long; keel-petals 5 mm. long, with a rounded apex; pod about 1 cm. long, 3 mm. broad, strigose, elliptic-oblong, acute at each end, short-stipitate, the stipe shorter than the calyx-tube.

TYPE collected at Ponchuelo Creek, New Mexico, July 4, 1908, *Standley 4181* (herbarium of the New York Botanical Garden).

This is closely related to *H. strigulosus* but differs in the white or purple-tinged (not ochroleucous) corolla, with a decidedly purple-tipped keel, and in the narrower pods with much shorter stipes. Macbride thought that this belonged to *H. Clementis* Rydb. and, on account of the similarity of the pod to that of *H. strigulosus*, made *H. Clementis* a variety of *Astragalus tenellus*. He had evidently not seen the type or a duplicate of the type of *H. Clementis*, but had seen specimens of *Baker 489* from Marshall Pass, Colorado, which evidently belong to *H. Clementis*. In our specimen of this number the pods are very immature, but a closer examination would have shown Macbride that Baker's plant and *Standley 4181* were not the same. In the type of *H. Clementis* the pods are half broader than in *H. Standleyi*, distinctly black-hairy and tapering at both ends, but the stipe if any is only a fraction of a millimeter long, i. e. the pod is subsessile; the corolla also is much larger. *Baker 489* also has black-hairy pods.

12. HOMALOBUS ACERBUS (Sheld.) Rydb. Macbride reduced this species to *Astragalus tenellus* forma *acerbus*, but had evidently seen no specimens of it. M. E. Jones has referred the type of *A. acerbus* in the Columbia Herbarium to *A. wingatanus* and expressed his views in print.* as follows: "*Astragalus acerbus* seems to be identical with *A. Dodgeanus* Jones, and the latter is not surely separable from *A. wingatensis* [*wingatanus*]." In *H. tenellus* and its closer relatives the corolla is ochroleucous (not a very important character); the racemes, together with the peduncles, seldom overtop the leaves to any extent; the pods are decidedly veiny; and the plants are inclined to blacken in drying. In *H. acerbus*, on the other hand, the corolla is white or purple-tinged; the racemes are twice to four times as long as the leaves; the venation of the pods is indistinct; and the plants show no inclination to blacken. The following specimens belong here:—

COLORADO: Glenwood Springs, 1893, *Saunders*; DeBeque, *Osterhout 4282*; Grand Junction, 1895, *M. E. Jones*.

13. HOMALOBUS DODGEANUS (M. E. Jones) Rydb. At present I have no authentic specimens of this species before me but, according to my memory, it is very closely related to *H. acerbus*, and Jones, as shown above, regards the two as identical. In fact Jones's own specimens, determined by him as *Astragalus Dodgeanus*, from Grand Junction, collected May 22, 1895, represent *H. acerbus* and are here listed under that species.

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* Proc. Calif. Acad. II. **5**: 636. 1895.

The type came from Thompson's Springs, Utah. The decidedly oblique pods and black-hairy calyx of *H. Dodgeanus* would make the species distinct enough, if these features should prove constant; otherwise the two species should perhaps be united. In this case Jones's specific name should be retained.

14. HOMALOBUS CLEMENTIS Rydb. See my notes under *H. Standleyi* above. Notwithstanding Macbride's remarks and his reduction of this species to a variety of *Astragalus tenellus*, I still consider it nearest to *H. wingatanus* and worthy of recognition. In both *H. wingatanus* and the allied *H. lancearius* the pod is acute at each end, as in *H. Clementis*, and a minute stipe is sometimes produced. In *H. lancearius*, in fact, this stipe may be fully as long as in *H. Clementis.* The following specimens may be cited:—

COLORADO: Saugre de Cristo, *Clements*; Marshall Pass, *Baker 489*; without locality, *C. H. Hall.*

15. HOMALOBUS WINGATANUS (S. Wats.) Rydb. To the specimens listed by Macbride the following may be added:—

COLORADO: Mancus, *Eastwood.*

UTAH: Monticello, *Rydberg & Garrett 9151, 9228.*

16. HOMALOBUS LANCEARIUS (A. Gray) Rydb. This species is still known with certainty only from the type collection: Beaver Dam, Arizona, 1877, *Palmer 114.* A flowering specimen from Allen Canyon in southeastern Utah, *Rydberg & Garrett 9309*, resembles the type very much but is doubtful in the absence of fruit. In the original description of *Astragalus lancearius*, Gray called attention to the fact that the species strongly resembled *A. filipes* in habit and in flowers, but that the pod was perfectly sessile. On this account it would have to be placed in the *Tenelli* group, probably near *H. wingatanus* and *H. acerbus.* Jones* claimed that the species was the same as *Astragalus recurvus* Greene, which on account of its completely two-celled fruit is a species of *Hamosa.* Later he† retracted his statement, adding that *A. lancearius* was "a good species but near *A. Rusbyi* Greene." The first part of his conclusion is correct but the latter part is far from the mark.

17. HOMALOBUS EPISCOPUS (S. Wats.) Rydb. Under *Astragalus Coltoni* Jones, Macbride makes the following statement:

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* Proc. Calif. Acad. II. **5**: 636. 1895.

† Contr. West. Bot. **8**: 12. 1898.

"Rydberg's reduction . . . of this species to *A. episcopus*, a plant with strictly sessile pods, is not understandable." The explanation of this reduction is as follows. In the herbarium of Columbia University there is a sheet labelled: "Coll. United States Department of Agriculture. *Astragalus Episcopus*, S. Watson, n. sp. Locality Utah. Collector, Capt. Bishop, 1872." The specimens on the sheet are more or less broken up into pieces but the habit is very similar to that of *A. Coltoni*, as represented by our specimens collected at Castle Gate by Jones. The plants are in flower, but the color of the corolla can not be determined. There is also a broken immature pod, showing a stipe nearly 1 cm. long. On the same sheet is a pocket containing two pods; one of these is mature and of exactly the same shape as the pods of *A. Coltoni* (except that the stipe is broken off), while the other is very young but shows a stipe 7 mm. long. On the pocket is written in what I take to be Watson's hand, "*Astragalus episcopus*, Wats. S. Utah. Capt. Bishop, 1873. pods." These specimens in the Columbia University Herbarium clearly belong to the same species as *A. Coltoni*. Macbride's statement that the pod of *A. episcopus* is "sessile" does not agree either with the type specimen or with Watson's description, which reads: "pod narrowly oblanceolate, compressed, 1¼ inches long, 2½ lines broad, acute at each end, very shortly stipitate, reflexed." Watson's description, however, agrees in every respect with the Columbia University specimens, except the words "very shortly;" for the stipe is rather long. As Watson also describes the flowers as being "purple or yellowish," he might have had a mixture, and if the specimens in the Columbia Herbarium were included in his conception of the species, this was certainly the case. The specimen in the Gray Herbarium is also fragmentary but shows a plant related to *H. lancearius*; its pod, however, is larger, 3 cm. long, and 5–6 mm. broad, tapering at both ends and very shortly stipitate, and the corolla is larger, being fully 12 mm. long.

18. HOMALOBUS VEXILLIFLEXUS (Sheld.) Rydb. This was originally described as *Astragalus pauciflorus* Hook.; since, however, there is an older *A. pauciflorus* Pallas., Hooker's specific name is not tenable in *Astragalus* and hence not in *Homalobus*. As the plant is well known no specimens need be cited.

H. miser (Dougl.) Rydb. should be withdrawn, at least provisionally. My conception of it was partly based on Gray's interpretation of the species, when he included under it *Lyall 7*, a specimen in flower only. Jones and Piper have referred this specimen to *Astragalus microcystis* A. Gray, a species of *Phaca*. I do not feel certain that their identification is correct or that Lyall's specimen really represents *Astragalus miser* Dougl. Since Gray placed the species among the *Homalobi* and since I at that time identified certain slender specimens in fruit with Lyall's plant, I admitted *H. miser* as valid. I now think that the true *A. miser* is still to be identified.

C. BOURGOVIANI

This group bears the name of *Debiles* in my Flora of the Rocky Mountains. It is desirable to change the name, however, since *Astragalus debilis* (Nutt.) A. Gray, as will be shown below, is an imperfectly known species.

19. HOMALOBUS BOURGOVII (A. Gray) Rydb. The habit and the black-hairy calyx and pod make this plant resemble a good deal *Astragalus alpinus* L. and *Phaca elegans* Hook., both now belonging to other genera. Except for the somewhat ridged valves of the pod the plant is a true *Homalobus*. In the alpine regions of the Canadian Rockies there grows a low, almost acaulescent form, with minute leaflets. This looks very unlike the ordinary form, but all grades between the two extremes are found.

20. **Homalobus retusus** sp. nov.

A perennial, with a slender caespitose rootstock; stems decumbent or ascending, 1–2 dm. long; stipules lanceolate or the lower ovate or triangular, connate, 1–2 mm. long; leaves 5–8 cm. long; leaflets nine to eleven, oblong to oval, often retuse or emarginate, 5–12 mm. long, 2–4 mm. wide, glabrous above, sparingly strigose beneath; peduncles 6–10 cm. long, slender; racemes short, five- to ten-flowered, bracts lanceolate, 2 mm. long; calyx black-hairy, the tube 2 mm. long, the teeth subulate, 1 mm. long; corolla purplish; banner 8–9 mm. long, obovate; wings 7–8 mm. long, the blade obliquely oblanceolate, with a long basal auricle; keel-petals slightly shorter, with a rounded apex; pod black-hairy, sessile, 8 mm. long, 3.5 mm. wide.

TYPE collected at Fort Selkirk, Yukon, July 20, 1899, *Tarleton 128, a & b* (herbarium of the New York Botanical Garden). The following specimens in flower may belong here:—

YUKON: Ranch Valley, *Gorman 1082;* White Horse, *Macoun 58429.*

When I transferred *Astragalus debilis* (*Phaca debilis* Nutt.) to *Homalobus,* I thought that the specimens above cited belonged to it and drew the characters of the pod from them. I have since found that they represent a species close to *H. Bourgovii.* M. E. Jones identifies *Phaca debilis,* with *Astragalus Bodini* Sheld., which is a true *Phaca* related to *P. microcystis.* A duplicate of the type of *P. debilis,* which is in the Torrey Herbarium, somewhat resembles *P. Bodini* in habit, but the calyx is not black-hairy and the leaflets are emarginate. Macbride admits *Astragalus debilis* as a member of the subgenus *Homalobus,* citing the following two species from Colorado: North Park, *Osterhout 3,* and Upper Platte, *Geyer 3.* The latter I have not seen but Osterhout's plant clearly belongs to *P. Bodini.* Osterhout had labelled it "*Astragalus debilis,*" apparently following Jones's interpretation. Until the fruit is discovered, I fear that *P. debilis* can not be fully interpreted.

Astragalus grallator S. Wats. is regarded by M. E. Jones as an abnormal form of *A. Haydenianus,* and I am inclined to agree to this view. In this case the species should be removed from *Homalobus.* The specimen of *A. grallator* in the Torrey Herbarium, so named by Watson, is a similar abnormal form of some other species.

INDEX TO AMERICAN BOTANICAL LITERATURE

1920-1922

The aim of this Index is to include all current botanical literature written by Americans, published in America, or based upon American material; the word America being used in the broadest sense.

Reviews, and papers that relate exclusively to foresty, agriculture, horticulture, manufactured products of vegetable origin, or laboratory methods are not included, and no attempt is made to index the literature of bacteriology. An occasional exception is made in favor of some paper appearing in an American periodical which is devoted wholly to botany. Reprints are not mentioned unless they differ from the original in some important particular. If users of the Index will call the attention of the editor to errors or omissions, their kindness will be appreciated.

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Brush, W. D. Utilization of basswood. U. S. Dept. Agr. Bull. 1007: 1–64. *pl. 1–7 + f. 1–7.* 5 Je 1922.

Bucher, G. C. Narrative of an ascent of Pico Turquino, Cuba. Jour. New York Bot. Gard. **23:** 81–91. Jl 1922.

Burnham, S. H. Lichens of the Lake George [New York] region. Bryologist **25:** 1–8, 34–37, 58–59, 72–78. 1922.
Includes several new combinations.

Buscalioni, L., & Muscatello, G. Studio monografico sulle specie americane del gen. *Saurauja*, Willd. (cont.) Malphigia **29:** 231–246. 1922.

Butler, O., & Smith, T. O. On the use of the acetates of copper as fungicides. Phytopathology **12:** 279–289. *f. 1.* 12 Au 1922.

Campbell, D. H. The vegetation of Australia and New Zealand. Sci. Mo. **15:** 481–511. *f. 1–9.* D 1922.

Chambers, C. E. Wild rice. U. S. Dept. Agr. Circ. 229: 3–16. *f. 1–9.* Au 1922.

Chaney, R. W. Notes on the flora of the Payette formation. Am. Jour. Sci. **204:** 214–222. S 1922.

Chapman, H. H. A new hybrid pine. Jour. For. **20:** 729–734. *f. 1–3.* N 1922.

Child, H. W. A New England occurrence of *Listera australis.* Rhodora **24:** 187, 188. 27 S 1922.

Cleland, R. E. The reduction divisions in the pollen mother cells of *Oenothera franciscana.* Am. Jour. Bot. **9:** 391–412. *pl. 25–27.* 30 Au 1922.

Cockerell, T. D. A. A new genus of fossil Liliaceae. Bull. Torrey Club **49:** 211–213. *f. 1.* 10 Au 1922.

Brachyruscus, gen. nov., from Colorado.

Cockerell, T. D. A. *Rudbeckia* and *Aquilegia.* Nature **110:** 278. *f. 1.* 26 Au 1922.

Cockfield, W. E. Sixty-mile and Laude Rivers area, Yukon. Geol. Surv. Canada Dept. Mines Mem. 123: 1–60. 1922. [Illust.]

Includes list of plants collected in region.

Cocks, R. S. A list of the shrubs of Louisiana. Jour. Arnold Arb. **3:** 173–182. D 1922.

Coffman, F. A. Pollination in alfalfa. Bot. Gaz. **74:** 197–203. *f. 1–5.* 16 O 1922.

Coker, W. C., & Beardslee H. C. The laccarias and clitocybes of North Carolina. Jour. Elisha Mitchell Soc. **38:** 98–126. *pl. 17–33.* S 1922.

Cooper, W. S. The broad-sclerophyll vegetation of California. Carnegie Inst. Washington Publ. 319: *1–124. f. 1–43.* 16 O 1922.

Czaja, A. T. Studien zur Apogamie leptosporangiater Farne. Ber. Deuts. Bot. Ges. **40:** 346–352. 1922.

Über die apogamie der *Pellaea atropurpurea* (L.) Link.

Danguy, P., & Chermezon, H. Sur quelques espèces et variétés nouvelles de la Republique de l'Equateur. Bull. Mus. Hist. Nat. **1922:** 432–439. 1922.

Includes 11 new species in various families.

Davidson, A. New botanical species from S[outhern] California. Bull. S. California Acad. Sci. **21:** 39–41. *pl. 2.* O 1922.

New species in *Langloisia* (1), *Allium* (1), and *Fritillaria* (1).

Davis, W. H. Staining germinating spores. Phytopathology **12:** 492–494. 5 D 1922.

Davis, W. H. The teaching of plant pathology. Proc. Iowa Acad. Sci. **27:** 81–84. 1920.

Davis, W. H. *Urocystis Agropyri* on redtop. Mycologia **14:** 279–281. *f. 1.* 1 S 1922.

Deane, W. *Vaccinium atrococcum*, forma *leucococcum*. Rhodora **24:** 228. 4 D 1922.

Dietel, P. Einige neue oder bemerkenswerte Uredineen. Ann. Myc. **20:** 293–295. 1922.

Includes 2 new American species.

Dixon, H. N. Miscellanea Bryologica.—VIII. Jour. Bot. **60:** 281–291. O 1922.

Dixon, H. N. The mosses of the Oxford University Expedition to Spitzbergen. Bryologist **25:** 86–89. 7 N 1922.

Dixon H. N. Note on a form of *Pottia Heimii* from Greenland. Bryologist **25:** 92, 93. 7 N 1922.

Dodge, B. O. A *Lachnea* with a botryose conidial stage. Bull. Torrey Club **49:** 301–305. *f. 1–7.* 11 O 1922.

Dodge, B. O. Studies in the genus *Gymnosporangium*—IV. Am. Jour. Bot. **9:** 354–365. *pl. 22 + f. 1–7.* 30 Au 1922.

Doran, W. L. Effect of external and internal factors on the germination of fungous spores. Bull. Torrey Club **49:** 313–340. *f. 1, 2.* 9 N 1922.

Dosdall, L. Occurrence of the pycnial stage of *Puccinia Taraxaci*. Bull. Torrey Club **49:** 235, 236. 31 Au 1922.

Douglass, A. E. Some topographic and climatic characters in the annual rings of the yellow pines and sequoias of the southwest. Proc. Am. Phil. Soc. **61:** 117–122. S 1922.

Duff, G. H. Development of the Geoglossaceae. Bot. Gaz. **74:** 264–291. *pl. 8–12.* 23 N 1922.

Dufrenoy, J. The occurrence of *Cronartium ribicola* in Europe. Phytopathology **12:** 302–305. 12 Au 1922.

Dupler, A. W. A bisporangiate sporophyll of *Lycopodium lucidulum.* Bot. Gaz. **74:** 331, 332. *f. 1.* 23 N 1922.

Dupler, A. W. Early embryogeny of *Reboulia hemisphaerica.* Bot. Gaz. **74:** 143–157. *f. 1–47.* 16 O 1922.

Dupler, A. W. The male receptacle and antheridium of *Reboulia hemisphaerica.* Am. Jour. Bot. **9:** 285–295. *pl. 14 + f. 1–24.* 12 Jl 1922.

Eaton, S. V. Sulfur content of soils and its relation to plant nutrition. Bot. Gaz. **74:** 32–58. *f. 1.* 15 S 1922.

Elliott, J. A., & Crawford, R. F. The spread of tomato wilt by infected seed. Phytopathology **12:** 428–434. *pl. 28 + f. 1, 2.* 17 O 1922.

Elmore, C. J. A comparison of German and American diatoms. Proc. Nebraska Acad. Sci. **5:** 65, 66. 1922.

Emig, W. H. Mosses of the Rocky Mountains Park, Banff, Alberta, Canada. Bryologist **25:** 61–66. 31 Jl 1922.

Eriksson, J. The connection between *Peridermium Strobi* Kleb. and *Cronartium ribicola* Dietr.,—is it obligate or not? Arkiv Bot. **18**^{2}**:** 1–40. *f. 1–6.* 8 Au 1922.

Essig, F. M. The morphology, development, and economic aspects of *Schizophyllum commune* Fries. Univ. California Publ. Bot. **7:** 447–498. *pl. 51–61.* 11 Au 1922.

Evans, A. W. Recent studies on certain species of *Riccia.* Bryologist **25:** 81–86. 7 N 1922.

Evermann, B. W. The conservation and proper utilization of our natural resources. Sci. Mo. **15:** 289–312. O 1922.

Farr, C. H. The meiotic cytokinesis of *Nelumbo.* Am. Jour. Bot. **9:** 296–306. *pl. 15 + f. 1.* 12 Jl 1922.

Fawcett, H. S. A new *Phomopsis* of *Citrus* in California. Phytopathology **12:** 419–424. *f. 1, 2.* 17 O 1922.

Fawcett, W. William Wright, a Jamaican botanist. Jour. Bot. **60:** 330–334. N 1922.

Fawcett, W., & Rendle, A. B. Notes on Jamaican plants (cont.). Jour. Bot. **60:** 351–363. D 1922.

Includes *Ternstroemia calycina,* sp. nov.

Fernald, M. L. The American variations of *Linnaea borealis.* Rhodora **24:** 210–212. 6 O 1922.

Fernald, M. L. Notes on the flora of western Nova Scotia, 1921. Rhodora **24:** 157–164, 165–180, 201–208. S, O 1922.

Fernald, M. L. *Polypodium virginianum* and *P. vulgare.* Rhodora **24:** 125–142. 6 S 1922.

Feudge, J. B. Notes on some San Bernardino plants. Bull. S. California Acad. Sci. **21:** 41, 42. O 1922.

Fox, H. M. *Lilium candidum.* Addisonia **7:** 51, 52. *pl. 250.* 30 D 1922.

Fox, H. M. *Lilium croceum.* Addisonia **7:** 63, 64. *pl. 256.* 30 D 1922.

Fox, H. M. *Lilium speciosum.* Addisonia **7:** 55, 56. *pl. 252.* 30 D 1922.

Frazier, W. C., & Fred, E. B. Movement of legume bacteria in soil. Soil Sci. **14:** 29–32. *pl. 1, 2.* Jl 1922.

Fries, T. C. E. Die Gasteromyceten der Juan Fernandez und Oster-inseln. Nat. Hist. Juan Fernandez & Easter Is. **2:** 59, 60. 1922.

Gail, F. W. Photosynthesis in some of the red and brown algae as related to depth and light. Publ. Puget Sound Biol. Sta. **3:** 177–193. *pl. 31–33.* 20 D 1922.

Gaines, E. F., & Stevenson, F. G. Rye-wheat and wheat-rye hybrids. Jour. Hered. **13:** 81–90. *f. 17–20.* 7 S 1922.

Galloway, B. T. Improved method of propagating the litchi. Jour. Hered. **13:** 201–206. *f. 1–5.* 12 D 1922.

Garcia, F., & Guevara, R. Pharmacodynamics of *Datura alba.* Philipp. Jour. Sci. **20:** 599–609. *pl. 1.* Je 1922.

Gardner, N. L. The genus *Fucus* on the Pacific coast of North America. Univ. California Publ. Bot. **10:** 1–180. *pl. 1–60.* 25 Ap 1922.

Includes 2 new species.

Gates, R. R. Some points on the relation of cytology and genetics. Jour. Hered. **13:** 75, 76. 7 S 1922.

Gericke, W. F. Magnesia injury of plants grown in nutrient solutions. Bot. Gaz. **74:** 110–113. 15 S 1922.

Gericke, W. F. Protective power against salt injury of large root systems of wheat-seedlings. Bot. Gaz. **74:** 204–209. 16 O 1922.

Gericke, W. F. Certain relations between root development and tillering in wheat; significance in the production of high-protein wheat. Am. Jour. Bot. **9:** 366–369. 30 Au 1922.

Girola, C. D. Cultivo de la yerba mate (*Ilex paraguariensis* St. Hil.). Bol. Minist. Agr. Nac. [Argentina] **27:** 247–261. Je 1922. [Illust.]

Gleason, H. A. *Lopezia hirsuta.* Addisonia **7:** 35, 36. *pl. 242.* 4 D 1922.

Gleason, H. A. *Trichosporum pulchrum.* Addisonia **7:** 43, 44. *pl. 246.* 4 D 1922.

Gleason, H. A. Vernonieae. N. Am. Fl. **33:** 47–110. 15 S 1922.

Includes 3 new species.

Glover, C. C. *Quamasia esculenta.* Addisonia **7:** 29, 30. *pl. 239.* 25 S 1922.

Goodspeed, T. H., & Clausen, R. E. Interspecific hybridization in *Nicotiana*—I. Univ. California Publ. Bot. **11:** 1–30. 10 Au 1922.

Gortner, R. A., & Hoffman, W. F. Determination of moisture content of expressed plant tissue fluids. Bot. Gaz. **74:** 308–313. 23 N 1922.

Graff, P. W. Philippine Basidiomycetes—V. Bull. Torrey Club **49:** 223–233. 31 Au 1922.

Graff, P. W. Unreported plants from Glacier National Park [Montana]. Bull. Torrey Club **49:** 175–181. 8 Jl 1922.

Gravelle, P. O. Nature study with the microscope. Nat. Hist. **22:** 549–557. D 1922. [Illust.]

Graves, E. W. A fern collecting trip in Cuba. Am. Fern Jour. **12:** 45–53. 11 S 1922.

Greider, A. Zur Frage des Anbaus von Faserpflanzen im Staate Sao Paulo [Brazil]. Tropenpflanzer 25: 70–72. Je 1922.

Greir, N. M. Preserving Indian Pipes [*Monotropa*] without discoloration. Rhodora **24:** 225, 226. 4 D 1922.

Grimes, E. J. Some interesting plants of the Virginia coastal plain. Rhodora **24:** 148–152. *pl. 138.* 11 S 1922.

Hagström, J. O. Potamogetonaceae, in Urban, I., Plantae Haitienses novae vel rariores a cl. Er. L. Ekman 1917 lectae. Arkiv Bot. **17**^{7}**:** 12–14. *f. 1.* 15 My 1922.

Includes *Potamogeton pulchelliformis*, sp. nov.

Hansen, A. A. Austrian field cress: a new weed in the United States. Torreya **22:** 73–77. *f. 1.* O 1922.

Roripa austriaca (Crantz) Spach.

Hanson H. C. Prairie inclusions in the deciduous forest climax. Am. Jour. Bot. **9:** 330–337. *f. 1, 2.* 12 Jl 1922.

Harger, E. B., Graves, C. B., Eames, E. H., Bissell, C. H., & Weatherby, C. A. Additions to the flora of Connecticut. Series 2. Rhodora **24:** 111–121. 28 Au 1922.

Harlan, H. V., & Pope, M. N. The germination of barley seeds harvested at different stages of growth. Jour. Hered. **13:** 72–75. 7 S 1922. [Illust.]

Harms, H. Über die von L. R. Gibbes aus Carolina beschriebenen Kakteen. Monats. Kakteenk. **32:** 123, 124. Au 1922.

Harshberger, J. W. Ecologic and morphological study of the clovers (*Trifolium*). Proc. Am. Phil. Soc. **61:** 136–150. *pl. 1–6.* S 1922.

Harvey, R. B. Growth of plants in artificial light. Bot. Gaz. **74:** 447–451. *f. 1, 2.* 21 D 1922.

Harvey, R. B. Growth of plants in artificial light from seed to seed. Science II. **56:** 366, 367. 29 S 1922.

Haupt, P. Manna, nectar and ambrosia. Proc. Am. Phil. Soc. **61:** 227–236. 1922.

Hedgcock, G. G., & Hunt, N. R. Notes on some species of *Coleosporium*—I. Mycologia **14:** 244–257. *pl. 21, 22.* 1 S 1922.

Heilborn, O. Notes on the cytology of *Ananas sativus* Lindl. and the origin of its parthenocarpy. Arkiv Bot. **17**^{11}**:** 1–7. *f. 1–3.* 15 My 1922.

Heilborn, O. Taxonomical and cytological studies on cultivated Ecuadorian species of *Carica.* Arkiv Bot. **17**^{12}**:** 1–16. *pl. 1.* 15 My 1922.

Includes 2 new species.

Hemmi, T. On the occurrence of *Mycosphaerella* wilt of muskmelons in Japan. Phytopathology **12:** 394–397. 11 S 1922.

Hentschel, E. Ueber den Bewuchs auf den treibenden Tangen der Sargassosee. Mittl. Zool.-Staat & Zool. Mus. Hamburg **38:** 1–25. 1921.

Hitchcock, A. S. Plant nomenclature. Jour. Bot. **60:** 316–318. N 1922.

Hoehne, F. C. Convolvulaceas dos hervários: Horto "Oswaldo Cruz," Museu Paulista e Commisão Rondon. Anex. Mem. Inst. Butantan [Brazil] Secc. Bot. **1**^{6}**:** 1–84, 93–97. *pl. 1–19.* N 1922.

Includes 12 new species.

Hollick, A. *Alnus rugosa.* Addisonia **7:** 25, 26. *pl. 127.* 25 S 1922.

Holttum, R. E. The vegetation of West Greenland. Jour. Ecol. **10:** 87–108. *pl. 3–5.* 26 My 1922.

Hopkins, E. F. The effect of lactic acid on spore production by *Colletotrichum Lindenmuthianum.* Phytopathology **12:** 390–393. *f. 1, 2.* 11 S 1922.

Vol. 50 No. 6

BULLETIN

OF THE

TORREY BOTANICAL CLUB

JUNE, 1923

The antherozoid of the genus Riccardia

W. N. Steil

(WITH FIVE TEXT FIGURES)

A number of unsuccessful attempts were made to obtain the antherozoids of *Riccardia pinguis* (L.) S. F. Gray, which was found growing in a swamp in the vicinity of Madison, Wisconsin. Finally, on May 20, 1919, from a single male plant motile antherozoids were obtained. At this time, a number of preparations were made by first inverting a slide with a drop of water containing the free-swimming antherozoids over the fumes of a 1 per cent osmic acid solution. The preparation was then exposed to the air, and as soon as the water was evaporated, the slide was stained with a dilute gentian violet solution. By this method it was easy to stain the cilia and the different parts of the body of the antherozoid. Good preparations were also obtained with the acid-fuchsin and safranin combination.*.

The antherozoid of *Riccardia pinguis* (FIG. 1) is very large as compared with that of other liverworts. The accompanying drawing of the antherozoid of *Marchantia polymorpha* L. (FIG. 2), represented by the same magnification as the antherozoid of the *Riccardia*, shows the great difference in size between the antherozoids of the two species and also that the cilia are of equal length and attached to the same point of the body of the antherozoid.

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* See Steil, Staining the antherozoid of the fern. Bot. Gaz. **65**: 562. *f. 1.* 1918.

[The BULLETIN for May (**50**: 159–196. *pl. 8*) was issued May 25, 1923.]

The major portion of the body consists of a long rod-like homogeneous-staining nucleus extending to almost the posterior part of the body, where it gradually tapers to a point. The extreme posterior portion consists of a cytoplasmic structure which also tapers to a sharp point. This is the vesicle which usually becomes more densely stained than the remainder of the cytoplasmic portions. A cytoplasmic band or filament extends from the vesicle for some distance towards the anterior end where it becomes gradually narrower. It was difficult to determine its forward limit. A study of spermatogenesis already begun will, no doubt, aid in deciding this doubtful point.

FIG. 1. An antherozoid of *Riccardia pinguis* in the uncoiled condition, × 1527.

At the anterior end of the body are attached the cilia; one a short distance from the end, and the other some distance farther back. The cilia are of unequal length, the posterior one being considerably longer than the other. The fact that the cilia are attached at different points and are of unequal length is of interest, since in these two respects the antherozoids of *Riccardia pinguis* seem to be unique among the archegoniates.

The anterior end of the body of the antherozoid, extending forward from the point where the longer cilium is attached, stains less intensely with the gentain violet. It appears, therefore, that this portion is at least partially cytoplasmic. A darker staining portion at the point of attachment of each cilium can always be observed when the antherozoid is not over-stained. Further studies of the development of the antherozoid will probably aid in determining the nature of the anterior portion of the antherozoid, including the blepharoplast, which at an early stage in spermatogenesis appears as a small spherical body.

FIG. 2. An antherozoid of *Marchantia polymorpha*, × 1527.

Although no detailed study has been made of the manner of swimming of the antherozoid, some observations may be worthy of mention. When the antherozoid moves from point to point, it is in the form of a funnel, the larger end of the funnel being at the anterior end (FIG. 3). The antherozoid is constantly rotating in the free swimming condition. Antherozoids were observed to remain motile for more than thirty minutes after they had been set free from the antheridia.

Many more male gametophytes of *Riccardia pinguis* were found in the vicinity of Madison in the spring of 1920, and from preparations obtained at this time the observations made the previous year were confirmed.

In the spring of 1921, a supply of male plants of *Riccardia pinguis* was obtained from Mr. Severin Rapp, of Sanford, Florida. Although there were some minor morphological differences between these male plants and those growing in this locality, the antherozoids of the two forms were exactly alike.

FIG. 3. An antherozoid of *Riccardia pinguis* in the free-swimming condition, × 1527.

For several years *Riccardia multifida* has been found growing on decaying wood in the same general region as *Riccardia pinguis*. Gemmae were produced abundantly by these plants, but antheridial branches were at no time discovered. Further observations could not be made on these plants since the species apparently disappeared from this locality where it was once found in abundance.

Both *Ricccrdia multifida* and *R. palmata* were, however, obtained from Mr. Rapp the past spring and some good preparations of the antherozoids of both species were obtained.

The antherozoid of *R. palmata* (Hedw.) Carruth. is almost as large as that of *R. pinguis*, although the body, as FIG. 4 shows, is much smaller in diameter. The cilia resemble those of the antherozoid of *R. pinguis*, being unequal in length and attached at different points. At the point of attachment of each cilium, there is an enlargement which becomes more intensely stained. The vesicle is somewhat rounded off and enlarged at the posterior end. There is present, approximately in the center of the vesicle, a very dense, nearly spherical body, which may also be readily observed in the living antherozoid.

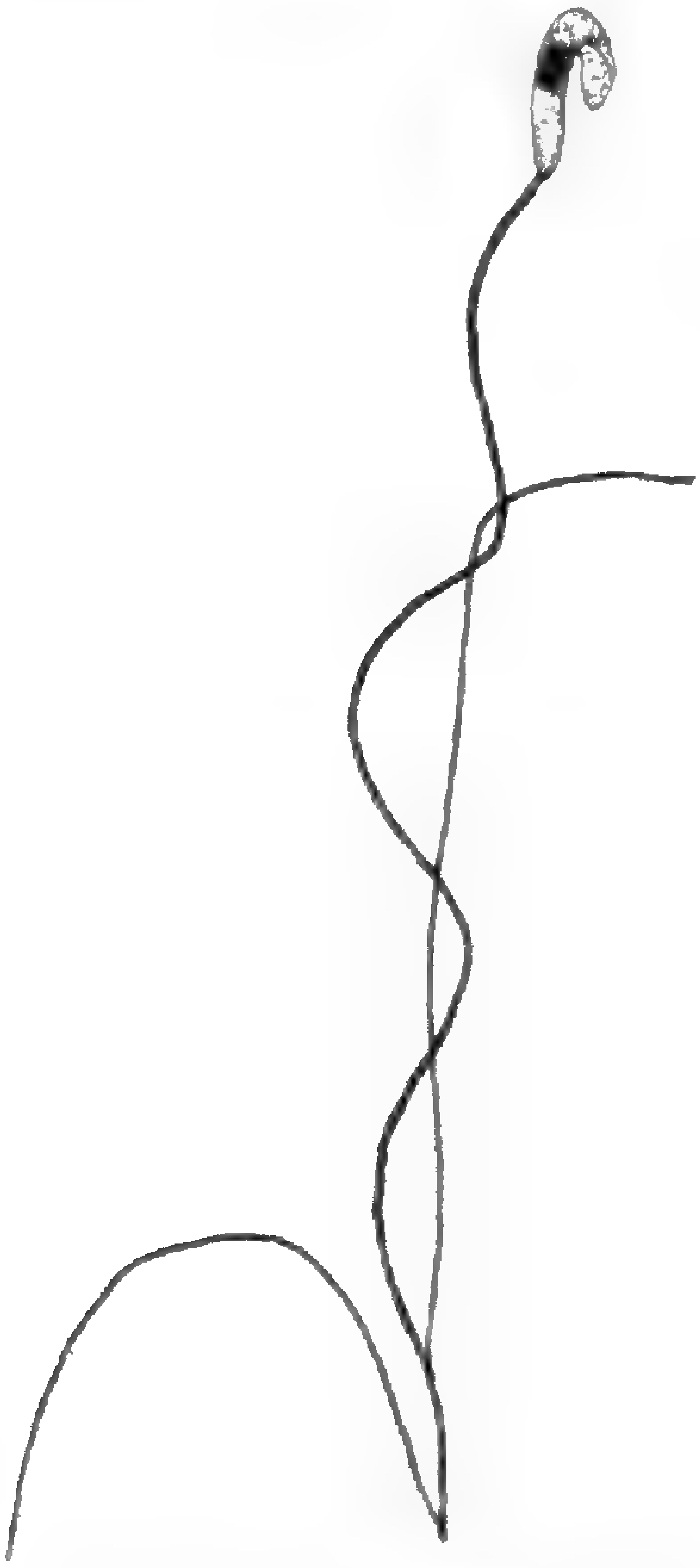

FIG. 4. An antherozoid of *Riccardia palmata*, × 1527

The antherozoid of *Riccardia multifida* (L.) S. F. Gray (FIG. 5) is much smaller than that of either of the other two species described. The cilia are, however, similar as to differences in length and points of attachment. A large body is found at the base of each of the cilia. The vesicle resembles that of the antherozoid of *R. palmata*, but it contains two nearly spherical bodies of different sizes; one, the smaller and nearer to the posterior end of the nucleus is almost homogeneous, the other and larger body is always in contact with the first body and is usually somewhat granular. Since the origin of these bodies has not been studied during the course of development of the antherozoid in any of the *Riccardia* species, no further statement can at this time be made concerning them.

When the antherozoids of these two species are set free from the antheridia, they are closely coiled in the form of a flat disk. As the antherozoid uncoils, ready for swimming, the body first forms a funnel but after a short interval takes on the form of a loosely coiled spiral. The peculiar funnel-like shaped of the body is characteristic, as has already been stated, of only the free swimming antherozoid of *Riccardia pinguis*. In this respect, the antherozoid of this species suggests that of the genus *Marsilia*.

Miss Clapp* studied the life history of *Riccardia pinguis* but made no detailed study of spermatogenesis. In her discussion, she states that her observations were confined to antherozoids which had not yet developed to maturity. No differences in length or points of attachment of the cilia were observed.

On account of the peculiar development of the gemmae in some of the *Riccardia* species, such as *R. multifida*, it has been suggested that these liverworts might be traced to algal origin, probably to the Chlorophyceae. The nature of the cilia of the antherozoid suggests a possible heterokont relationship.

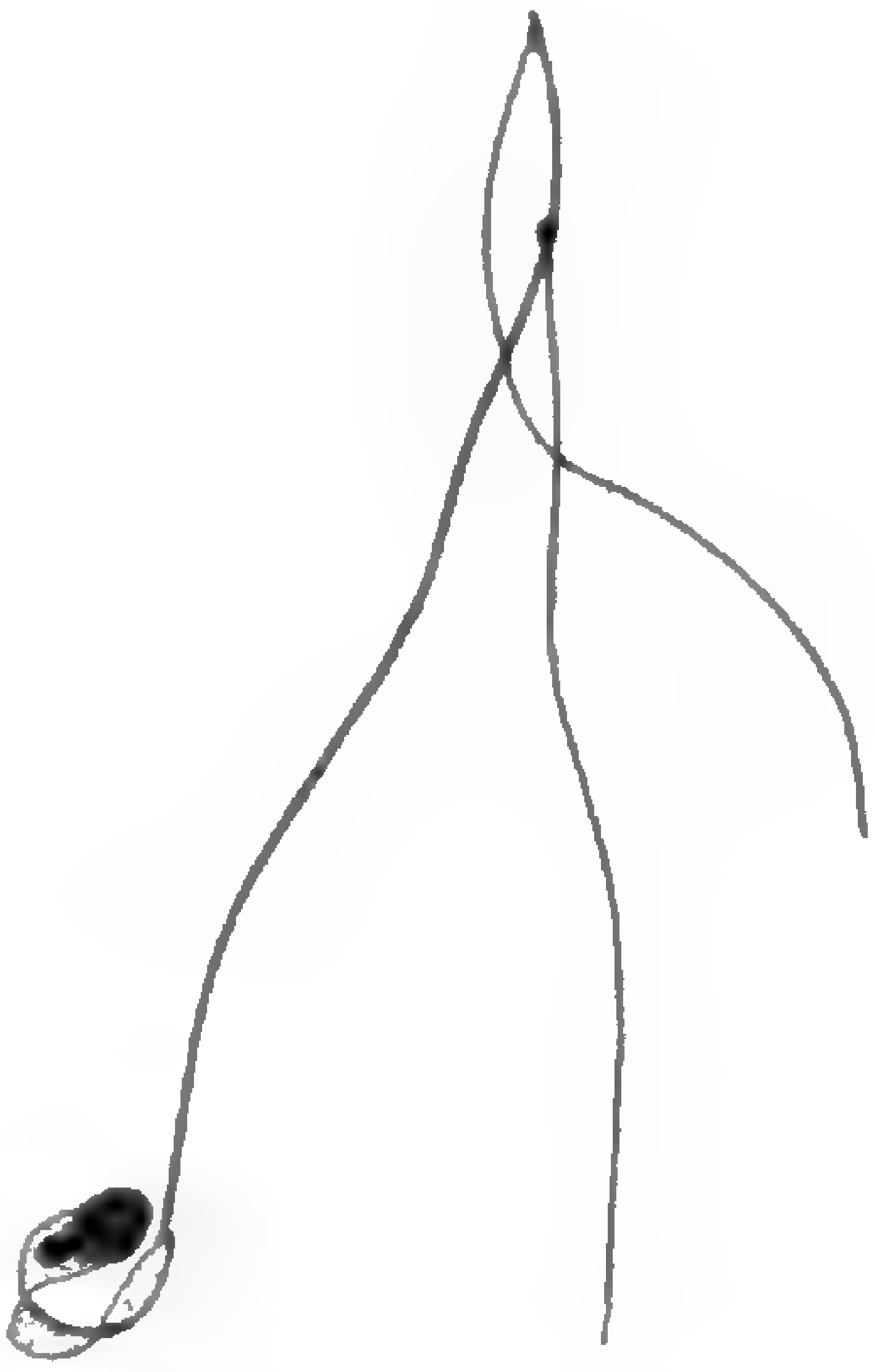

FIG. 5. An antherozoid of *Riccardia multifida*. × 1527.

Although the antherozoids of only three species have been studied, it is very likely that these are typical for the genus *Riccardia*. A study of other members of the Jungermanniales may result in the discovery of antherozoids similar to those here reported.

The writer wishes to thank Dr. A. M. Showalter of the Department of Botany, University of Wisconsin, and Mr. Severin Rapp of Sanford, Florida, for assistance in obtaining material, and Dr. A. W. Evans and Miss Caroline Haynes for identifying some of the specimens.

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* The life history of *Aneura pinguis*. Bot. Gaz. **54**: 177–193. *pl. 9–12.* 1912.

Two new composites from Florida

S. F. Blake

(WITH PLATE 9)

Lacinaria Ohlingerae Blake, sp. nov.

Perennial, 60–90 cm. high, the stem puberulous; leaves very numerous, linear, 1–2 mm. wide, punctate, glabrous; heads large, about 2.5 cm. high, about 25-flowered, turbinate, racemose or cymose-panicled; involucre 1.5–2 cm. high, the phyllaries rounded or the innermost obtuse, punctate, appressed, herbaceous with narrow, scarious, purplish, ciliolate margins; achenes densely pubescent, 7–9 mm. long; pappus bristles finely plumose under a lens.

Root tuberous-thickened, sometimes 3-lobed, 2.5–4.5 cm. long, about 1 cm. thick; stems 1-3 or more, slender, erect, 60–90 cm. high, rather densely incurved-puberulous, gland-dotted, simple or cymosely branched in the inflorescence, very leafy; leaves all narrowly linear, gradually decreasing in size above, 1–5.5 cm. long, 1–2 mm. wide, acute or acutish, callous-tipped, sessile, thick, 1-nerved, often twisted, densely punctate, glabrous; heads mostly 8 to 18, racemose on bracteolate pedicels 0.5–5 cm. long, or cymose-panicled on elongate erect 1 to 7-headed peduncles; involucre turbinate or in fruit turbinate-subglobose, about 7-seriate, graduate, 1.5–2 cm. high, the outermost phyllaries small, suborbicular, rather loose, the others oval or obovate to cuneate-oblong, 2-5 mm. wide, broadly rounded or the innermost obtuse, not mucronulate, appressed, all herbaceous, densely punctate, essentially glabrous dorsally, with narrow, scarious, usually purplish, ciliolate margins; disk 2.2–2.5 cm. high, 22-25-flowered; corollas rose-purple, 1.4–2 cm. long, sessile-glandular, the tube and throat slenderly trumpet-shaped, the teeth ovate, obtusish, 4-veined, 5.5 mm. long, 2.5 mm. wide (limb in flower 1–1.1 cm. wide); achenes narrowly obconic, 10-ribbed, 7–9 mm. long, densely and griseously spreading-pilosulous, gland-dotted between the ribs; pappus bristles numerous, 2-seriate, finely plumose, whitish, 1.5 cm. long; anther appendages very small.

TYPE in the U. S. National Herbarium, No. 1,116,795, collected in scrub formation nine miles southeast of Frostproof, Polk County, Florida, November 1, 1922, by Mrs. F. E. Ohlinger. Duplicates in the Gray Herbarium and the herbarium of the New York Botanical Garden.

Ample material of this beautiful plant has been received through Mr. F. L. Lewton from the collector, Mrs. F. E. Ohlinger of Frostproof, Florida. The species is nearest *L. scariosa* (L.) Hill, but differs markedly in its uniformly very narrowly linear leaves, as well as in its larger heads and much larger corollas and achenes. The nodding of some of the heads shown in the plate, which is drawn from a photograph of the type specimen, is undoubtedly due to the fact that the stem was bent backwards in growth. The narrowly linear obtusish style branches are 11 mm. long, the decidedly unequal stigmatic lines only about 4 mm. long. The minutely emarginate anther tips are about 0.2 mm. long.

Flaveria pinetorum Blake, sp. nov.

Glabrous perennial; leaves narrowly linear, 3–7.8 cm. long, 0.5–2 mm. wide; panicle small, dense, essentially naked; phyllaries 5; receptacle naked; ♀ flowers 0–1, ☿ 9–12; disk corollas about 3 mm. long, subglandular-puberulous; achenes equal, 1–1.4 mm. long.

Slender perennial, the root short, about 5 mm. thick, the stems few or solitary, ascending or erectish, sometimes decumbent and rooting below, 20–40 cm. long, simple below the inflorescence, glabrous except for the puberulous inflorescence; lower internodes 2–13 mm. long, the middle and upper 3–6 cm. long; leaves opposite, connate at base, narrowly linear or very narrowly oblanceolate-linear, 3–7.8 cm. long, 0.5–2 mm. wide, acutish, entire or obscurely denticulate above, fleshy, 1-nerved, erect or the lower usually reflexed; heads rather numerous, 4 mm. high, in a small ternately divided cymose panicle 1.5–5.5 cm. wide, the bracts linear-subulate, 7 mm. long or less, the pedicels about 1 mm. long or less; phyllaries 5, sometimes with 1–3 small bractlets at base, equal, oval-oblong, 4 mm. long, obtuse or rounded, carinate, about 6-nerved, glabrous; receptacle small, flattish, naked; ligule usually 0, sometimes 1, yellow, the tube 1 mm. long, the lamina obovate-elliptic, subentire, 6-veined, reflexed, 3 mm. long, 1 mm. wide; disk corollas 9–12, yellow, puberulous with subglandular hairs, 2.8–3.2 mm. long (tube 1–1.2 mm. long, throat cylindric below, funnelform-campanulate above, 1.5 mm. long, teeth 5 or sometimes 4, ovate, 0.5 mm. long); achenes all alike, blackish, glabrous, 1–1.4 mm. long.

TYPE in the U. S. National Herbarium, No. 1,028,688, collected in moist pineland, vicinity of Fort Myers, Lee County, Florida, December 14, 1919, by Paul C. Standley (No. 18909).

ADDITIONAL SPECIMEN EXAMINED:—

FLORIDA: Low pinelands, Alva, Lee County, Nov. 25, 1917, *Mary E. Francis 156.*

The nearest relative of this species, both geographically and systematically, is *Flaveria floridana* J. R. Johnston, a stout annual 5–10 dm. high, with broader leaves, leafy-bracted inflorescence, and glabrous disk-corollas. The only other species which might be confused with it, *F. linearis* Lag., which also occurs in Florida, is taller and has only "2"–7 disk flowers.

Another plant, *Standley 12859,* from the type locality, may be referable to this species, but is decidedly abnormal. The stout stem is woody, with grayish exfoliating bark. The late heads are about 18-flowered, and bear 6 or 7 pales, similar to the phyllaries, on the outer edge of the receptacle inside the outermost series of flowers.

Explanation of plate 8

LACINARIA OHLINGERAE Blake

FIG. *a.* Type, about ½ natural size.
FIG. *b.* Corolla, about natural size.
FIG. *c.* Corolla lobes, about × 2.
FIG. *d.* Achene, about natural size.
FIG. *e.* Portion of pappus bristle, about × 10.
FIG *f.* Stamens, about × 8.

LACINARIA OHLINGERAE BLAKE

The taxonomic and morphologic status of Ophioglossum Alleni Lesquereux

ARTHUR HOLLICK

(WITH PLATES 10–12)

About fifty years ago Lesquereux described, without any accompanying illustration, an imperfect fossil plant specimen from the Miocene Tertiary shales of Florissant, Colorado, under the name *Ophioglossum Alleni.*[*] The description was as follows:

> Leaf, elliptical, narrowed by a curve to the acute base; shorter and broader than in *O. vulgatum* L., of our time, with the same areolation.
>
> The leaf is about 3 cent. long (point broken), a little more than 2 cent. broad, marked in the middle by the remnant of a fruiting pedicel . . .

Subsequently the same author redescribed and figured the specimen under the name *Salvinia Alleni*,[†] and remarked: "By its form, its areolation, its size, all its characters, indeed, it is remarkably similar to *Salvinia reticulata* Heer."[‡] His amended description was as follows:

> Leaves oval, rounded in narrowing to the base; lateral veins, none visible, areolae large, irregularly square or equilateral, inordinately distributed.
>
> Leaf about three and a half centimeters long, twenty-two millimeters broad, of a thin substance, with a thick middle nerve and irregularly quadrate meshes, formed of very distinct black nervilles, the primary ones more or less in right angle to the middle nerve, with oblique, generally parallel veinlets between them . . . .

Later he listed and figured two other, more perfect specimens,[§] with the following brief comment:

> The species is common and has been obtained in large well-preserved specimens by the different collectors. The leaves are merely variable in size, obtuse or slightly emarginate at the apex, topped by the point of the excurrent nerve.

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[*] U. S. Geol. Survey Terr., Sixth Ann. Rept. 1872: 371. 1873.

[†] U. S. Geol. Survey Terr. Rept. vol. **7** (The Tertiary Flora): 65. *pl. 5, f. 11.* 1878. Reproduced on PLATE 10, FIG. 1.

[‡] Flora Tertiaria Helvetiae **3**: 156. *pl. 145, f. 16.* 1859. Reproduced on PLATE 10, FIG. 4.

[§] U. S. Geol. Survey Terr. Rept. vol. 8 (The Cretaceous and Tertiary Floras): 136. *pl. 21, f. 10, 11.* 1883. Reproduced on PLATE 10, FIGS. 2, 3.

In 1894 I had occasion to examine the figures and descriptions of this and other fossil species described under, or referred to, the genus *Salvinia*, and in a paper on the subject I referred Lesquereux' species to the genus *Tmesipteris*[*] and incidentally compared it with *Salvinia reticulata* (Ettingshausen) Heer, above mentioned, which Heer had suggested was, apparently, specifically identical with a fragmentary leaf or pod originally described by Ettingshausen under the genus *Dalbergia*;[†] but the resemblance to a pod did not impress me at the time.

In 1913, Professor T. D. A. Cockerell,[‡] in a discussion of the fauna and flora of the shales in which the species was originally discovered and from which the specimens subsequently collected were obtained, remarked:

> The so-called *Tmesipteris alleni* (Lx.) Hollick, although common, can not be referred to any genus known to those who have examined it. It has nothing whatever to do with *Tmesipteris*, nor does it belong to *Salvinia* or *Ophioglossum*, as placed by Lesquereux. It may be known for the present as *Carpolithes alleni* (Lx.).

Thus it was given its fourth generic appellation—one that suggested similarity in appearance to a carpel or capsule or pod-like organism of some kind.

In 1919 Florin,[§] in a paper on fossil Salvinias, expressed an opinion similar to that expressed by Cockerell—to the effect that the taxonomic status of Lesquereux' species was too uncertain to warrant its reference to any well-defined genus—and relegated it to the comprehensive fossil genus *Phyllites*, under the name *P. alleni* (Lesquereux) Florin (loc. cit. p. 254). The fifth generic name was thus applied in connection with the species—a name, apparently, meant to indicate that the author intended to suggest that it probably represented a foliar organ.

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[*] Fossil Salvinias, including description of a new species. Bull. Torrey Club **21**: 253–257. *pl. 205.* 1894.

[†] *Dalbergia reticulata* Ettingshausen, Beitrag zur Kenntniss der Fossilen Flora von Tokay. Sitzb. K. Akad. Wiss. [Wien.] Math.-Naturwiss. Cl. **11**^{4}: 813. *pl. 4, f. 5.* 1853. Reproduced on PLATE 10. FIG. 5.

[‡] The Fauna of the Florissant (Colorado) Shales. Am. Jour. Sci. **36**: 498–500. 1913.

[§] Eine Uebersicht der Fossilen *Salvinia*-Arten, mit besonderer Berücksichtigung eines Fundes von *Salvinia Formosa* Heer in Tertiär Japans. Bull. Geol. Inst. Upsala **16**: 249–260. *pl. 11.* 1919.

Recently Professor Cockerell* called attention to the fact that, in connection with certain specimens of the species, there could be detected a peculiar protuberance or body, apparently attached to the midrib, near the middle, in regard to one of which he remarked (loc. cit. pp. 211–212):

> It looks like a small berry, with the contents extruded. . . Probablythe riddle would never have been solved but for the discovery of a younger specimen . . . This . . . shows that we have to do neither with a leaf, frond nor pod, but with a cladode. Attached to the midrib is an indistinct mass, presumably a thin bract, upon which can be seen a dark object . . . which seems to agree very closely with the flower of *Ruscus* . . . The genus Ruscus [has] . . . lanceolate to ovate sharply pointed cladodes . . . . At first sight the venation seems quite different from that of the fossil, *but if we imagine the Ruscus cladode broadened and abbreviated until the principal veins are nearly or quite transverse instead of longitudinal, the correspondence is exact.*†

Based upon this course of reasoning a new genus was evolved, and Lesquereux' multi-generic species became *Brachyruscus Alleni* (Lesquereux) Cockerell (loc. cit. p. 212)—the sixth binomial under which it was described and discussed. Incidentally it may also be noted that this last change of name definitely transferred the species from the Pteridophyta to the Spermatophyta and changed it from a frond, a leaf, or a fruit to a cladode. The question whether or not this last change of name should be accepted as the final word in regard to its probable taxonomic and morphologic status did not, however, appear to be answered conclusively or satisfactorily, based as it was on a frank appeal to the imagination to supply the necessary evidence. Also the naïvely worded footnote on page 212 appeared to be more or less of the nature of a challenge. In any event the statements and conclusions set forth in the paper certainly called for a critical examination of all of the available facts and their faithful presentation, without any attempt to connect them with any preconceived theory and without any appeal to the imagination to supply any features in the specimens that might be poorly preserved or lacking.

During a recent visit to the United States National Museum I was enabled to examine some fifty specimens of the species in

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* A new genus of fossil Liliaceae. Bull. Torrey Club **49**: 211–213. *f. 1.* 1922.

† The italicising is mine.

question, all of them from the type locality at Florissant, Colorado. Among these I had no difficulty in finding a dozen or more that showed, either distinctly or indistinctly, the presence of some kind of a body, as described by Professor Cockerell. Nine were selected for illustrating the critical characters, all of which were photographed and are reproduced, natural size, on PLATE 10, FIGS. 6–11, and on PLATE 11, FIGS. 1–3; and the latter three were also enlarged so as to show the characters more clearly. The three enlargments are reproduced on PLATE 11, FIGS. 1a–3a. The salient characters that they may be seen to reveal are: (1) a system of reticulate nervation, with the nerves of uniform rank throughout; and (2) either an indistinct thickening or a well defined, flattened spheroidal body (occasionally two), located toward the middle of the foliaceous organ.

The general appearance of the specimens, however, strongly suggests that they represent a flattened pod, or a detached carpel of a pod, rather than a foliaceous organ, to which are attached either immature, or imperfect, or mature and perfect seeds. In certain of the specimens, as in those represented on PLATE 11, FIGS. 1, 1a, and 3, 3a, the seedlike bodies are apparently in the superior position and are impressed on the exposed surface of the specimens. In others, as represented on PLATE 11, FIGS. 2, 2a, they appear to occupy the inferior position and are more or less masked by the overlying tissue. The superior position is also indicated in the specimens depicted on PLATE 10, FIGS. 10, 11, and the inferior position in FIGS. 6–9 on the same plate. The latter figures also appear to represent more or less immature or imperfect specimens; and in the specimen represented by FIG. 8 the overlying tissue near the middle was carefully chipped away from what appeared to be some kind of a body beneath, but nothing was revealed except some obscurely defined ridge and furrow markings that appear to represent a slight thickening or expansion of the median nerve or rib.

On PLATE 12, FIG. 1, is shown a pressed capsule of *Staphylea trifolia* Linnaeus, and in FIG. 2 the exterior of a detached carpel of *Koelreuteria bipinnata* Franchet. In each may be seen the surface inequalities due to the underlying seeds. FIG. 3 represents the exterior of a carpel of *Koelreuteria paniculata* Laxman; FIG. 4, the interior with seeds attached to the alate expansion of the midrib; FIG. 5, the latter flattened by pressure; FIG. 6, the same with seeds detached. FIG. 7 is a reproduction of Cockerell's figures illustrating his description of *Brachyruscus*, and FIG. 8, a drawing of a cladode of *Ruscus aculeatus* Linnaeus, with infloresence attached. A comparison between the last two figures hardly seems to suggest, even with the assistance of an earnest effort of the imagination, that there could be any near relationship between the specimens that they represent; and, in any event, it is evident that, if the description and figures of *Brachyruscus* correctly describe and depict the specimen selected by the author as the type of the genus, *Brachyruscus Alleni* Cockerell can not possibly be either congeneric or morphologically identical with *Ophioglossum Alleni* Lesquereux. The author has, however, provided for this contingency to a certain extent, in the footnote previously mentioned, which should be read in this connection.

Incidentally, on PLATE 12, FIG. 9, is a drawing of a bract of *Dobinia vulgaris* Hamilton, showing the character of the nervation and a fructification attached to the midvein, in order that it may perhaps be recognized and accepted, in preference to the cladode of *Ruscus*, as the morophological equivalent and a possible family relative of *Brachyruscus*.

In view of the facts here presented if anyone should deem it necessary to coin a seventh generic name for *Ophioglossum Alleni*, based upon its resemblance to capsules or carpels of species of certain genera included in the Staphyleaceae and Sapindaceae, the responsibility will rest on him, not on me. The already established name, which is descriptive of what the species appears to morphologically simulate and which is therefore properly applicable, is *Carpolithes Alleni* (Lesquereux) Cockerell.

Explanation of plates 10–12

PLATE 10

SALVINIA ALLENI (Lesquereux) Lesquereux
[= *Ophioglossum Alleni* Lesquereux]

FIG. 1. U. S. Geol. Survey Terr. Rept. Vol. **7** (The Tertiary Flora): *pl. 5. f. 11.* 1878.

FIG. 2. Idem. Vol. **8** (The Cretaceous and Tertiary Floras): *pl. 21, f. 10.* 1883.

FIG. 3. Idem. *f. 11.*

SALVINIA RETICULATA (Ettinghausen) Heer

FIG. 4. Flora Tertiaria Helvetiae **3**: *pl. 145, f. 16.* 1859.

DALBERGIA RETICULATA Ettinghausen

FIG. 5. Sitzb. K. Akad. Wiss. [Wien] Math.-Naturwiss. Cl. **11**[4]: *pl. 4, f. 5.* 1853.

SALVINIA ALLENI (Lesquereux) Lesquereux

Reproductions of photographs, natural size, of specimens from the type locality at Florissant, Colorado.

FIG. 6. Showing indications of immature or imperfectly developed fructification. U. S. Nat. Mus. No. 36693.

FIG. 7. Idem. U. S. Nat. Mus. No. 36690.

FIG. 8. Idem., with overlying tissue removed. U. S. Nat. Mus. No. 36692.

FIG. 9. Showing indications of more maturely developed fructification. U. S. Nat. Mus. No. 36694.

FIG. 10. Showing mature fructification. U. S. Nat. Mus. No. 36691.

FIG. 11. Idem. U. S. Nat. Mus. No. 36688.

PLATE 11

SALVINIA ALLENI (Lesquereux) Lesquereux

Reproductions of photographs of specimens from the type locality at Florissant, Colorado, showing mature fructifications.

FIG. 1. Natural size. U. S. Nat. Mus. No. 36695.

FIG. 1a. Same specimen, × 2.

FIG. 2. Natural size, U. S. Nat. Mus. No. 36689.

FIG. 2a. Same specimen, × 2.

FIG. 3. Natural size. U. S. Nat. Mus. No. 50277.

Fig. 3a. Same specimen, × 2.

PLATE 12

STAPHYLEA TRIFOLIA Linnaeus

FIG. 1. Capsule, natural size, compressed, showing inequalities due to included seeds; distal end upward. From a specimen in the herbarium of the New York Botanical Garden, collected at Knoxville, Tennessee, in April, 1878, by Albert Ruth, No. 358.

KOELREUTERIA BIPINNATA Franchet

FIG. 2. Carpel, natural size, compressed, showing outer surface with inequalities due to included seed; distal end downward. From a specimen in the herbarium of the New York Botanical Garden, collected in Central China, 1885-88, by Angust Henry, No. 7591.

KOELREUTERIA PANICULATA Laxman

Carpel, natural size, under varied conditions; distal ends downward From a tree in the grounds of the U. S. Department of Agriculture, Washington, D. C., collected in August, 1922, by Arthur Hollick.

FIG. 3. Outer surface.

FIG. 4. Inner surface, with seeds attached to a late expansion of the midrib.

FIG. 5. Same, flattened by pressure.

FIG. 6. Same, with seeds detached.

BRACHYRUSCUS ALLENI (Lesquereux) Cockerell

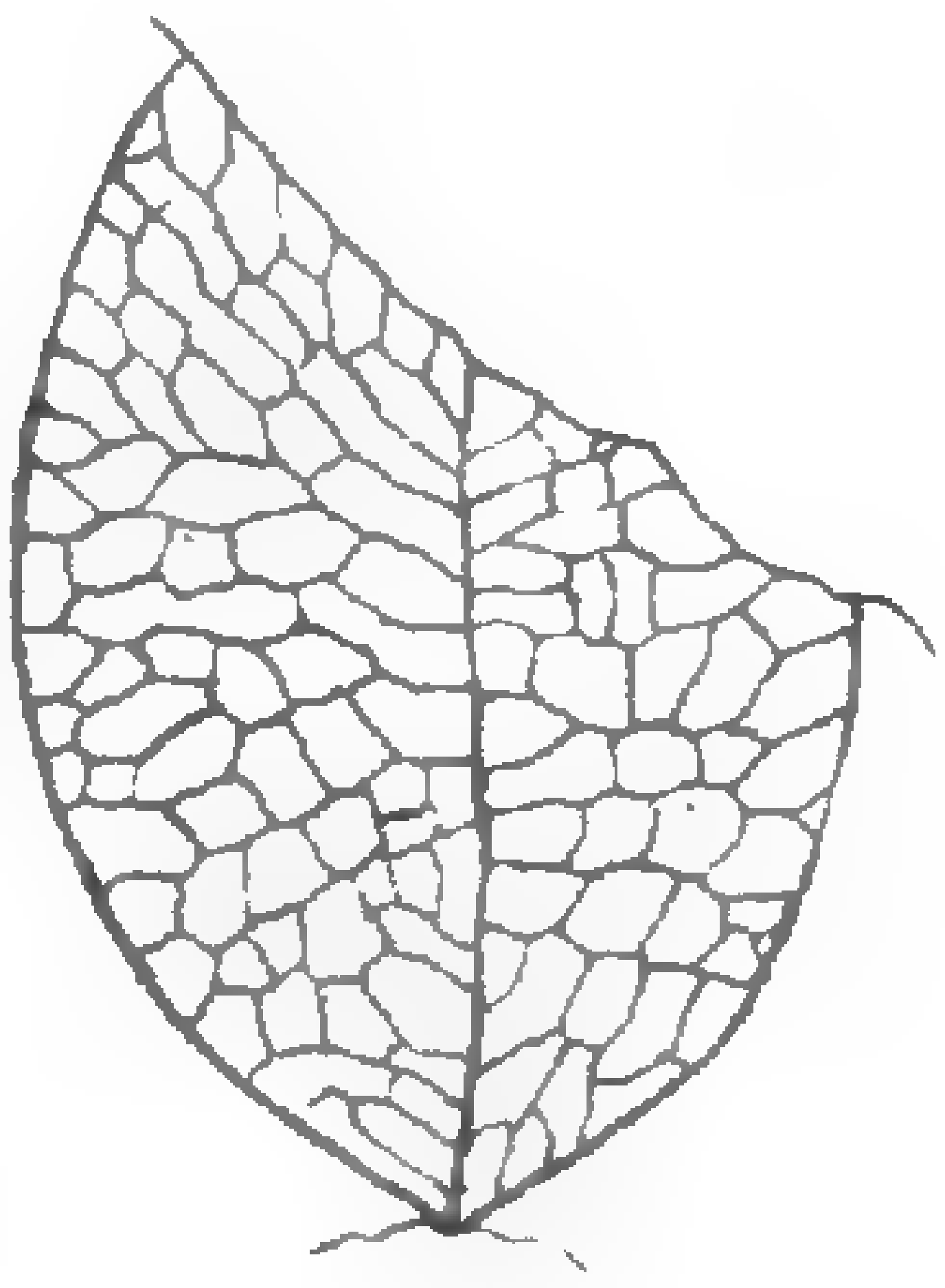
FIG. 7. Bull. Torrey Club **49:** *f. 13, A-D.* 1922.

RUSCUS ACULEATUS Linnaeus

FIG. 8. Cladode, natural size, upper surface, showing inflorescence attached to the median nerve; distal end upward. From a cultivated specimen in the herbarium of the New York Botanical Garden, collected at Montpellier, France.

DOBINEA VULGARIS Hamilton

FIG. 9. Bract, natural size, upper surface, showing fructification; distal end upward. From a specimen in the herbarium of the New York Botanical Garden, collected in Nepal, India, probably in 1821, by Nathaniel Wallich.



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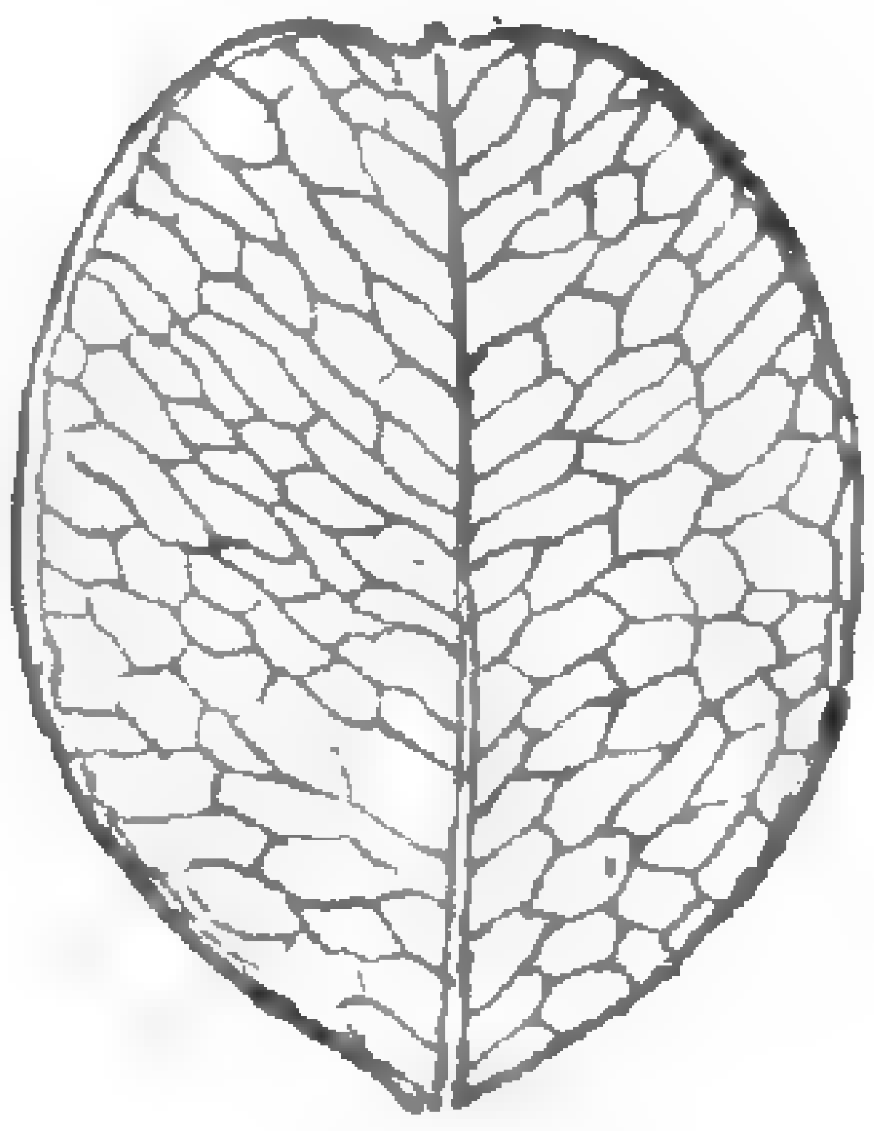

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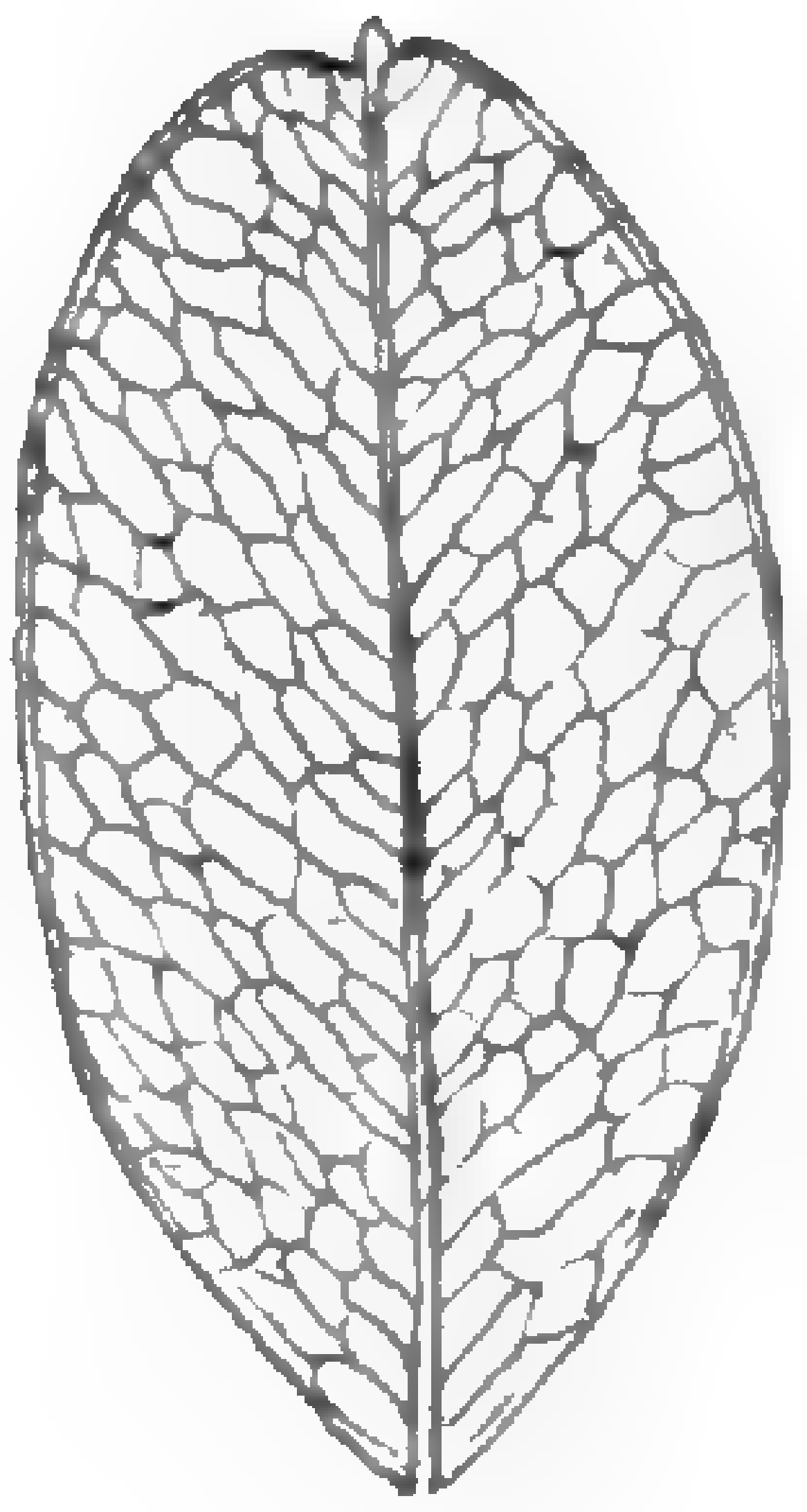

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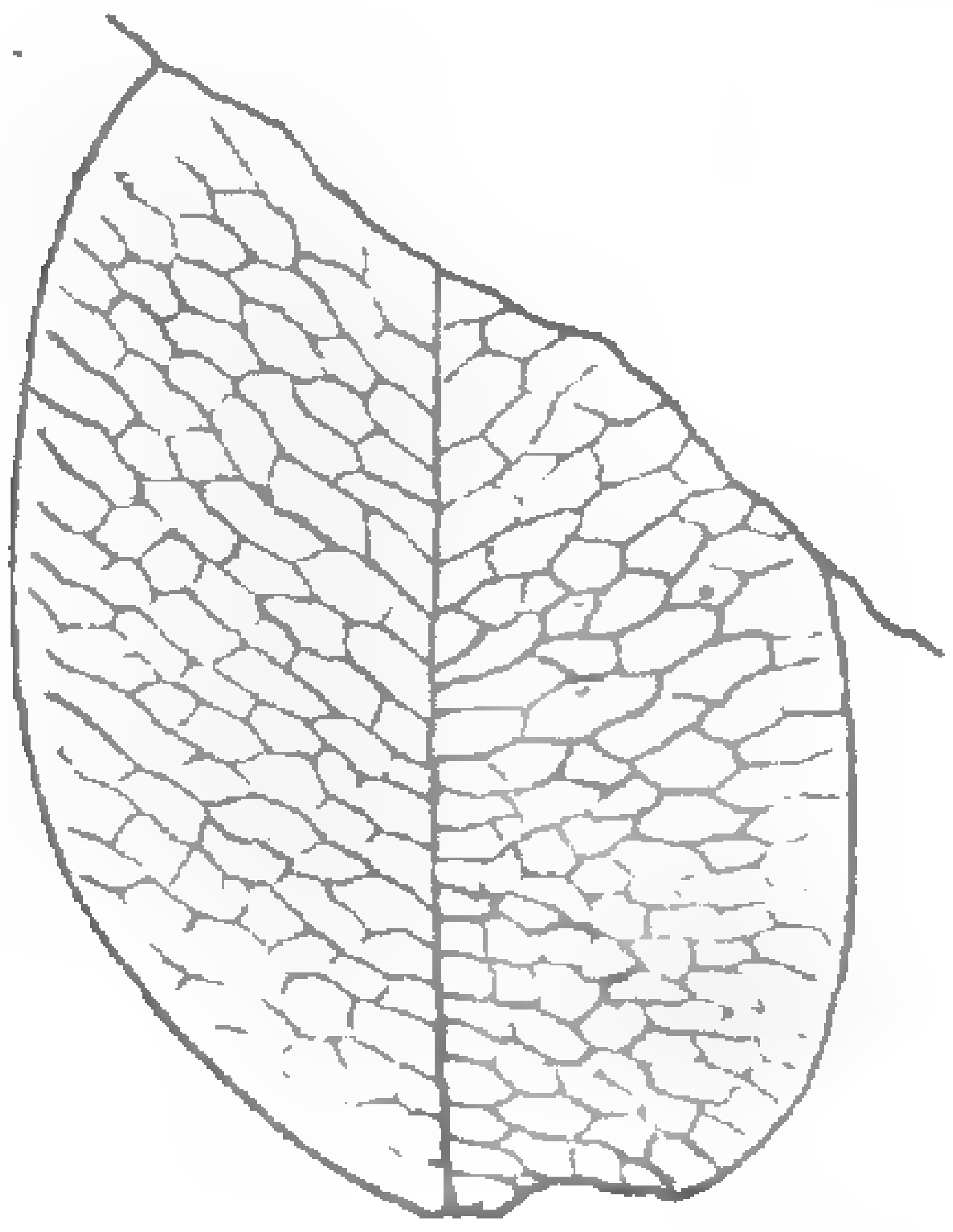

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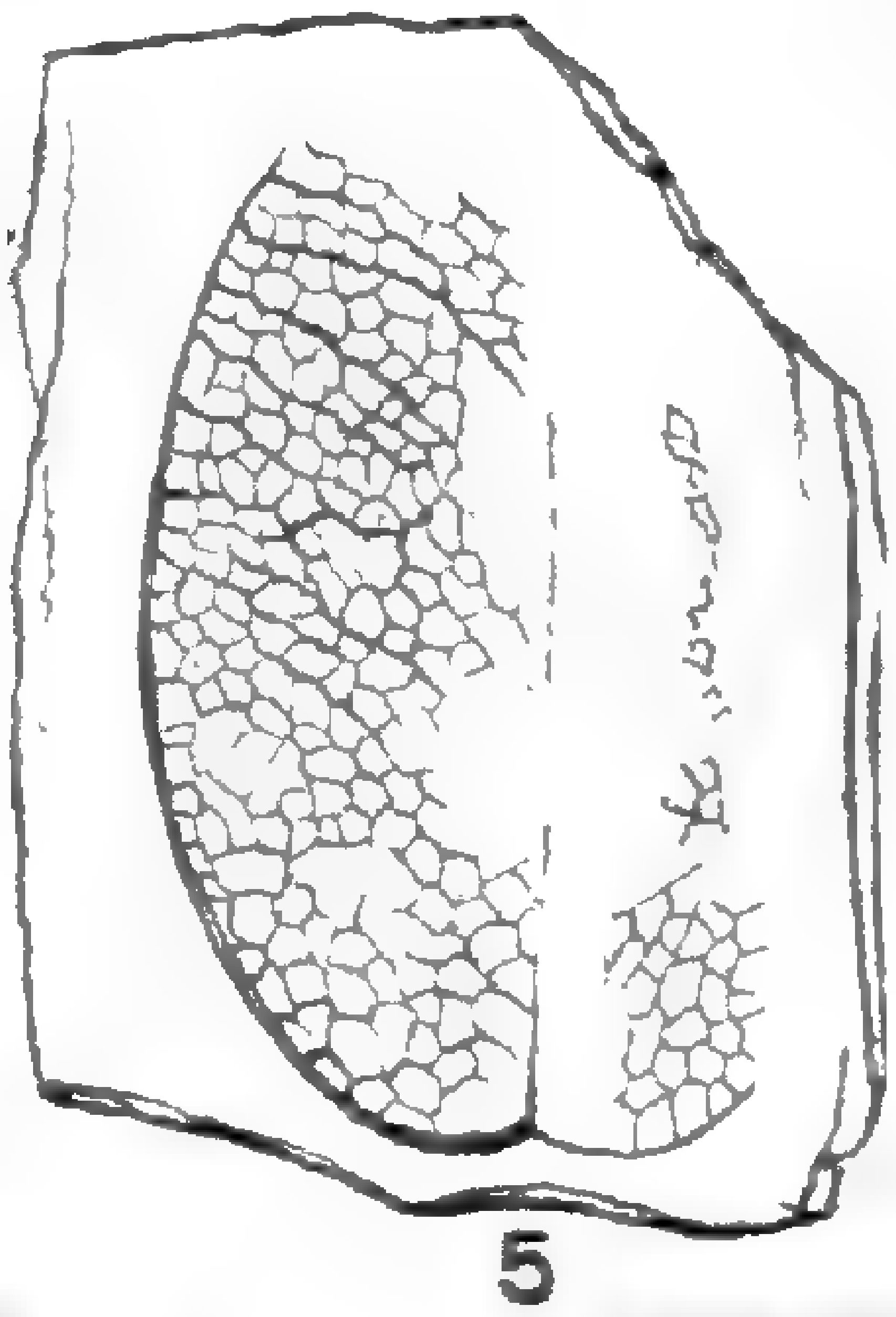

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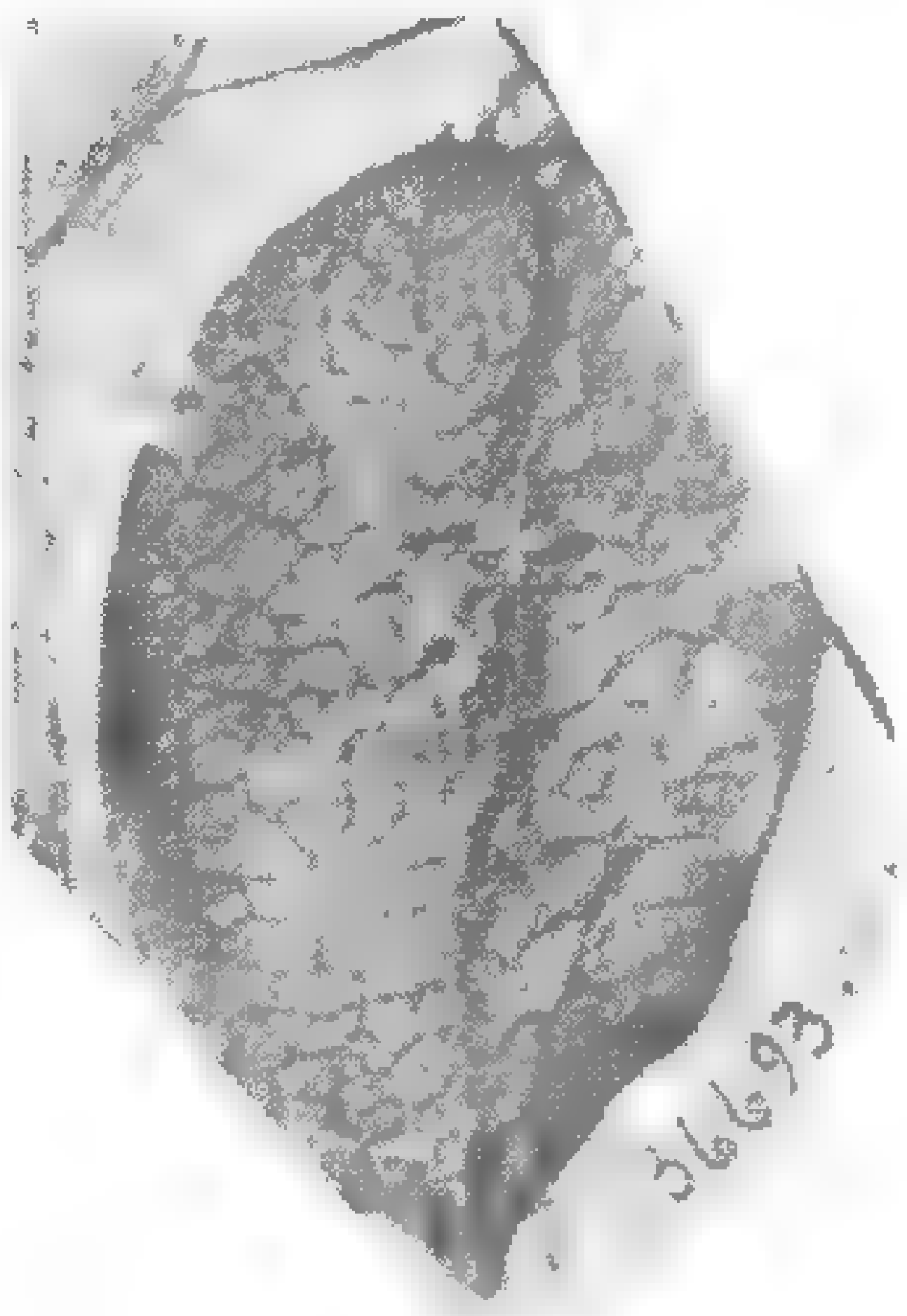

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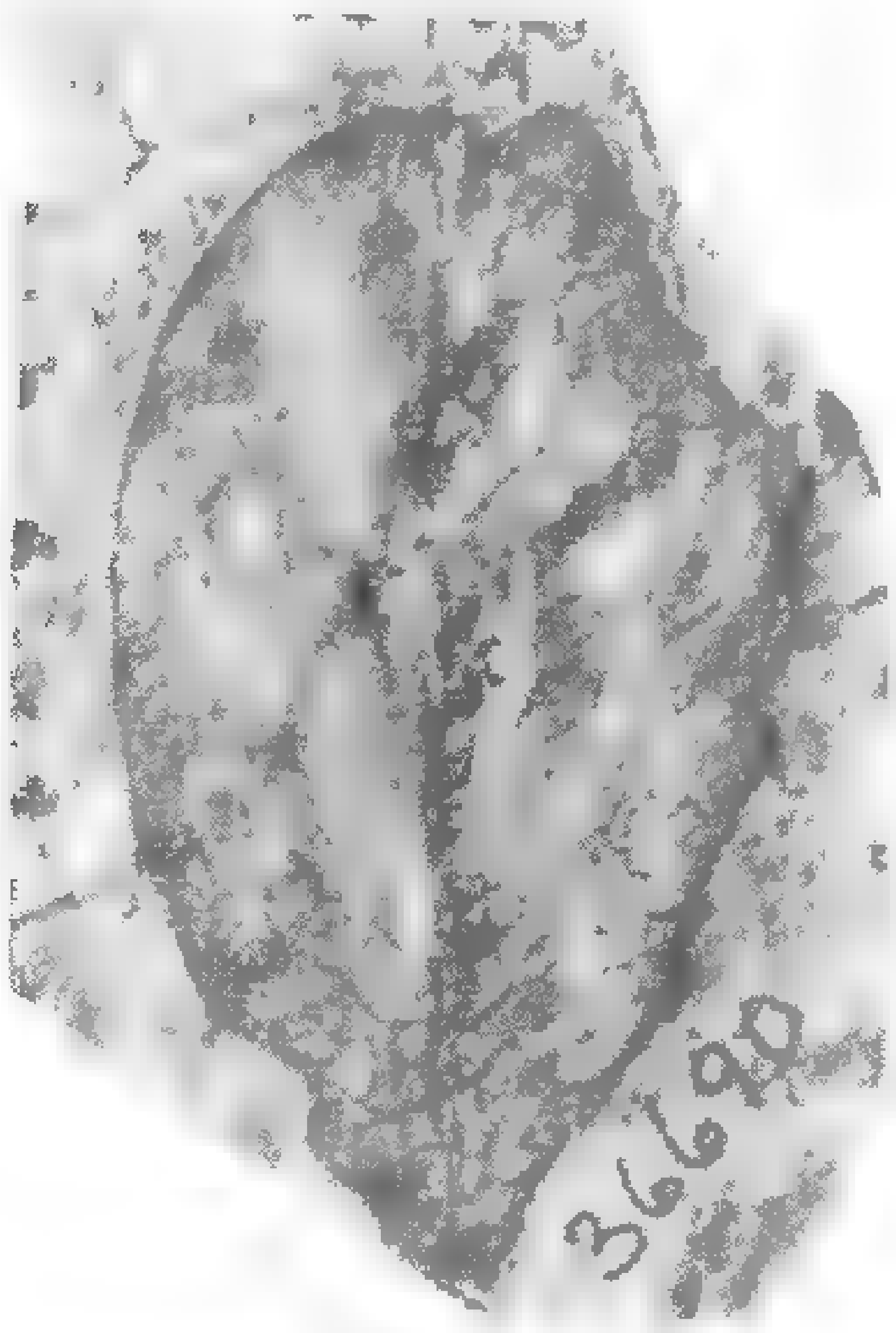

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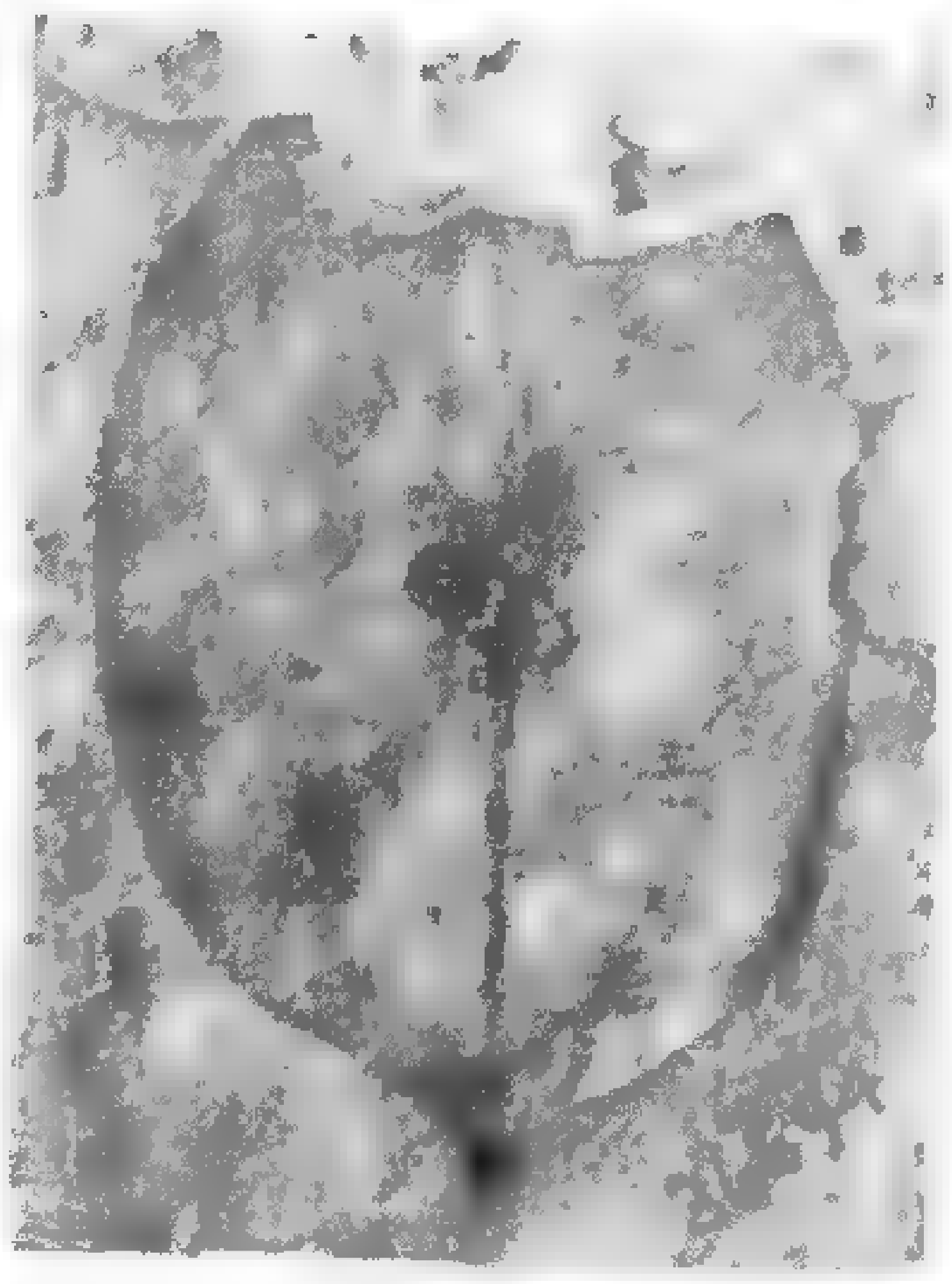

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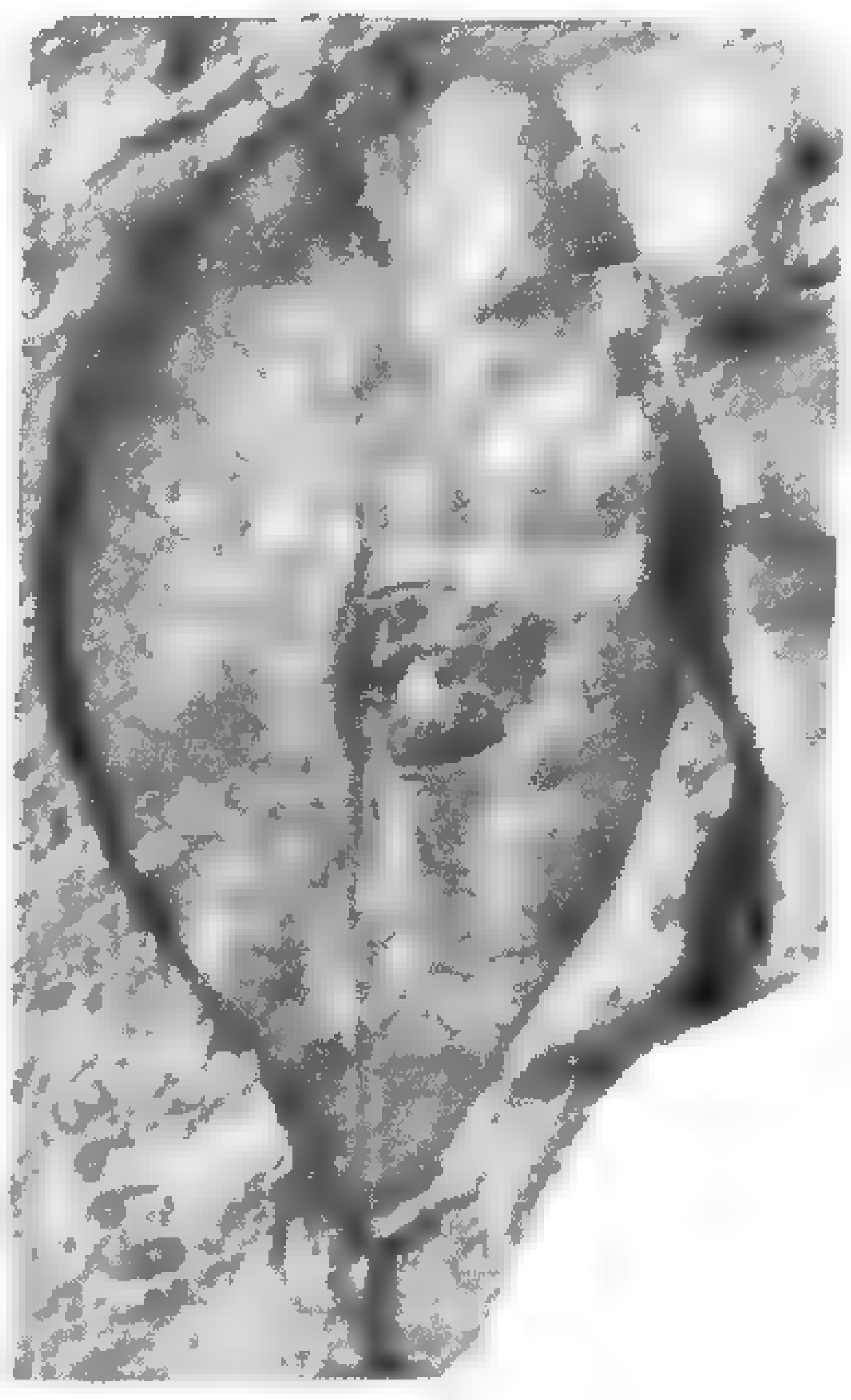

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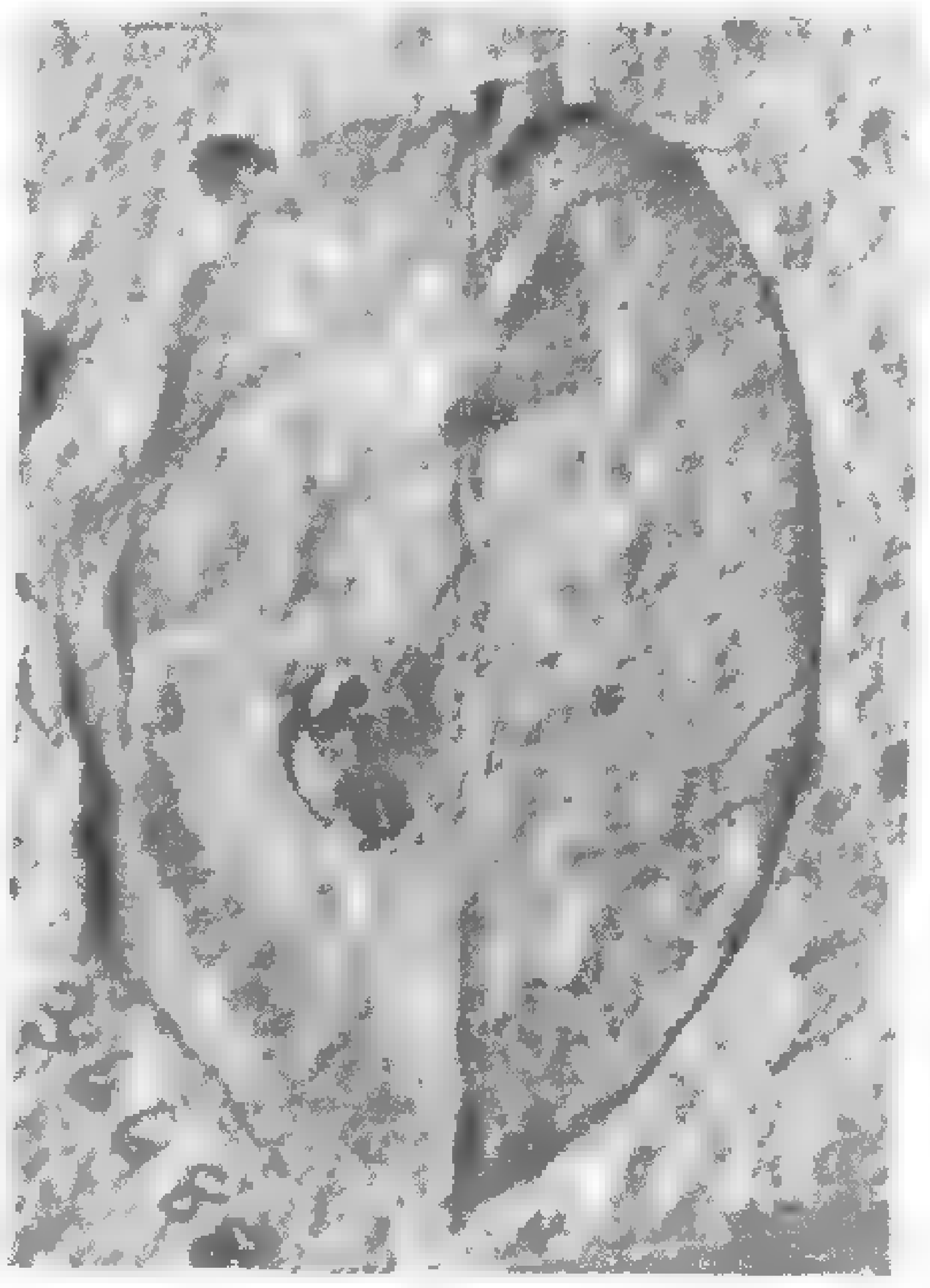
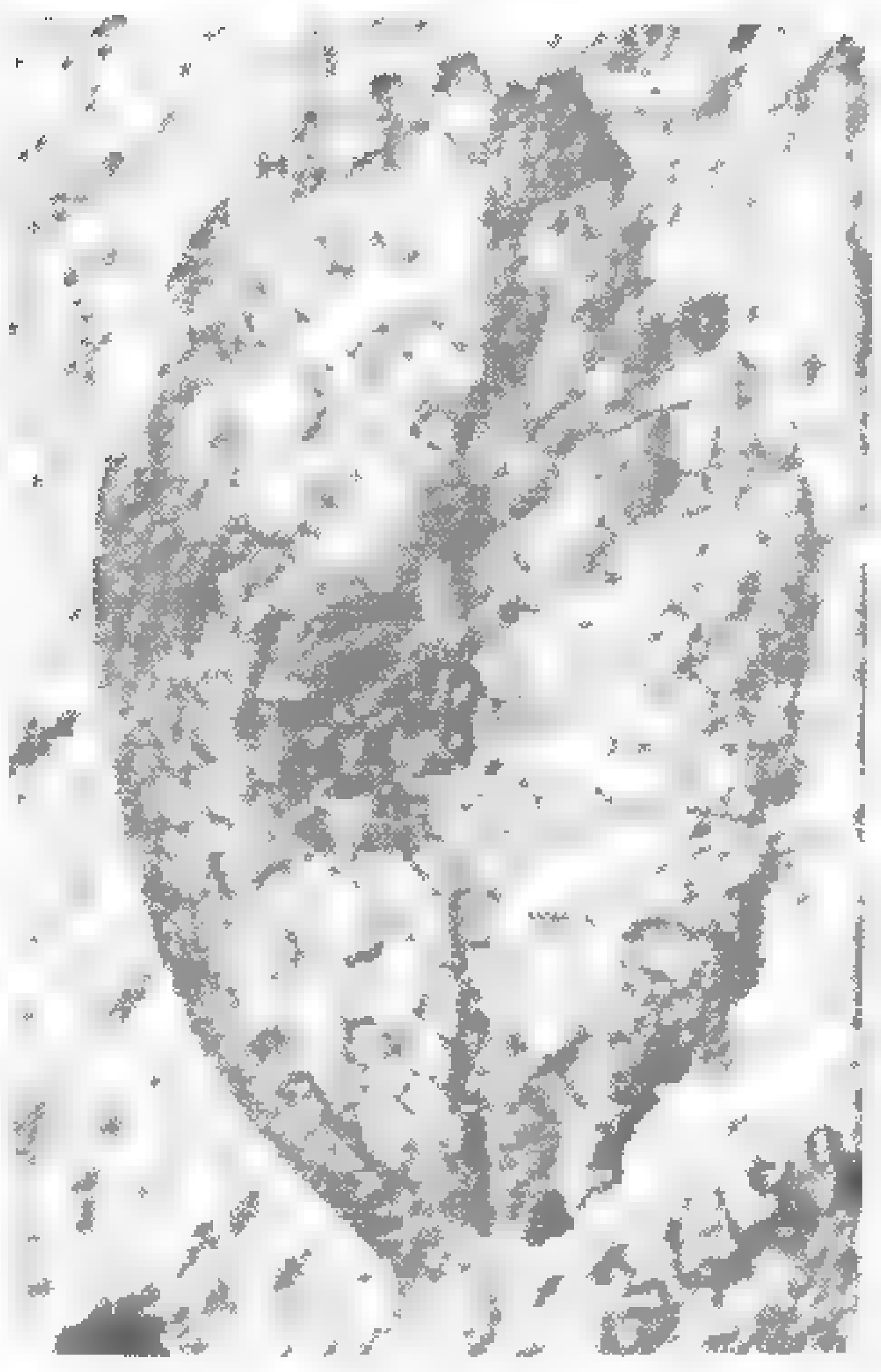


11

HOLLICK: STATUS OF OPHIOGLOSSUM ALLENI

1



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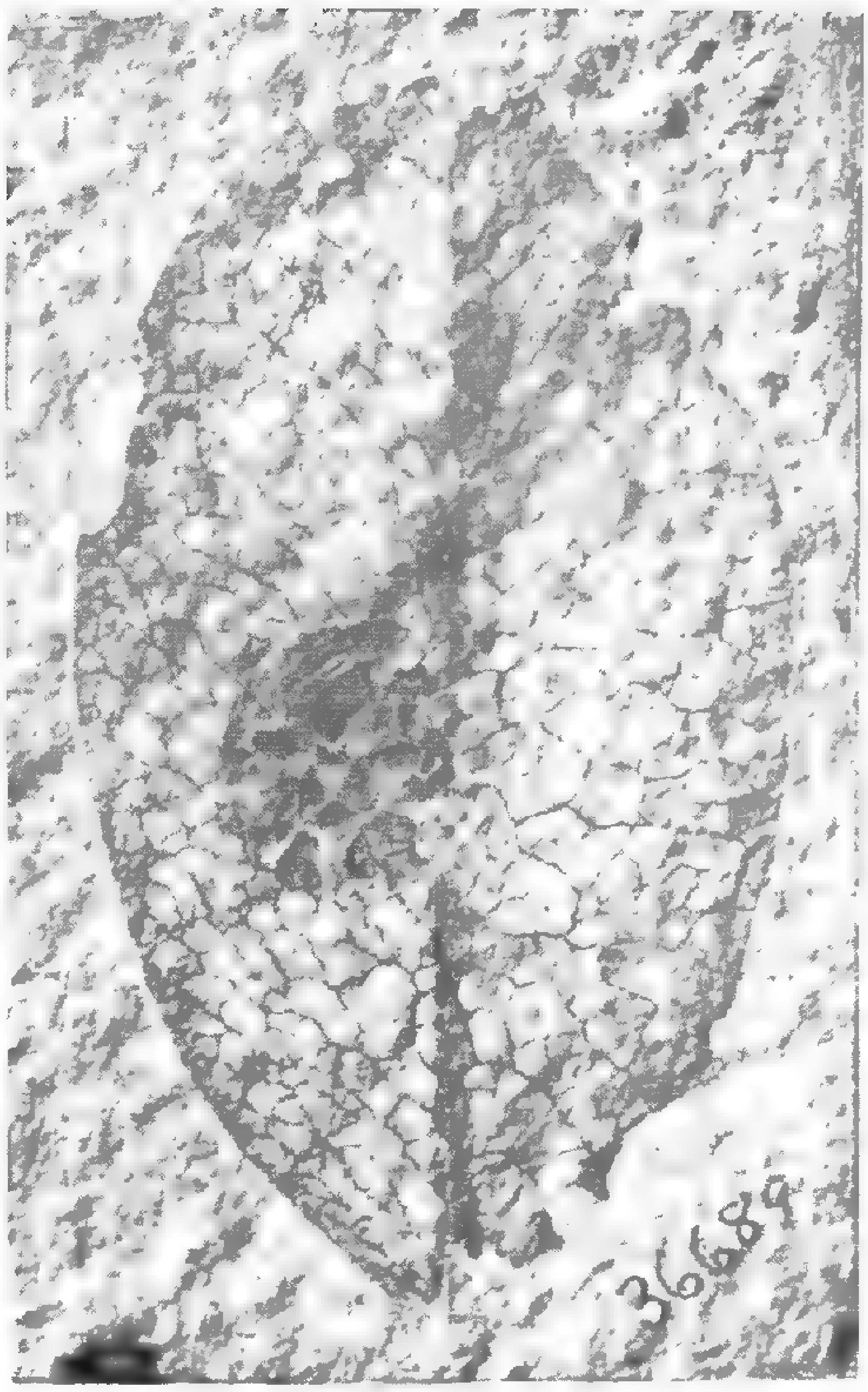

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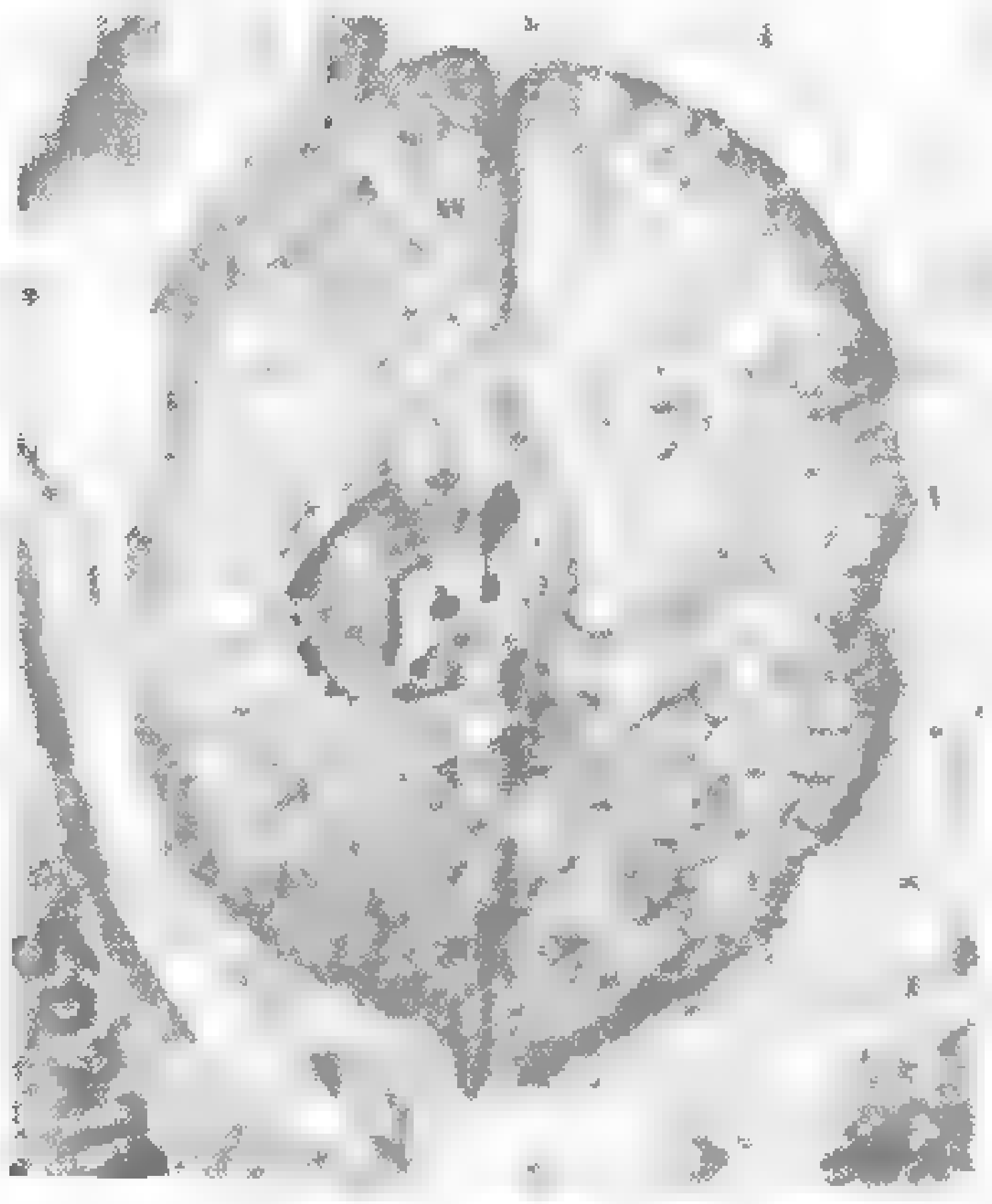
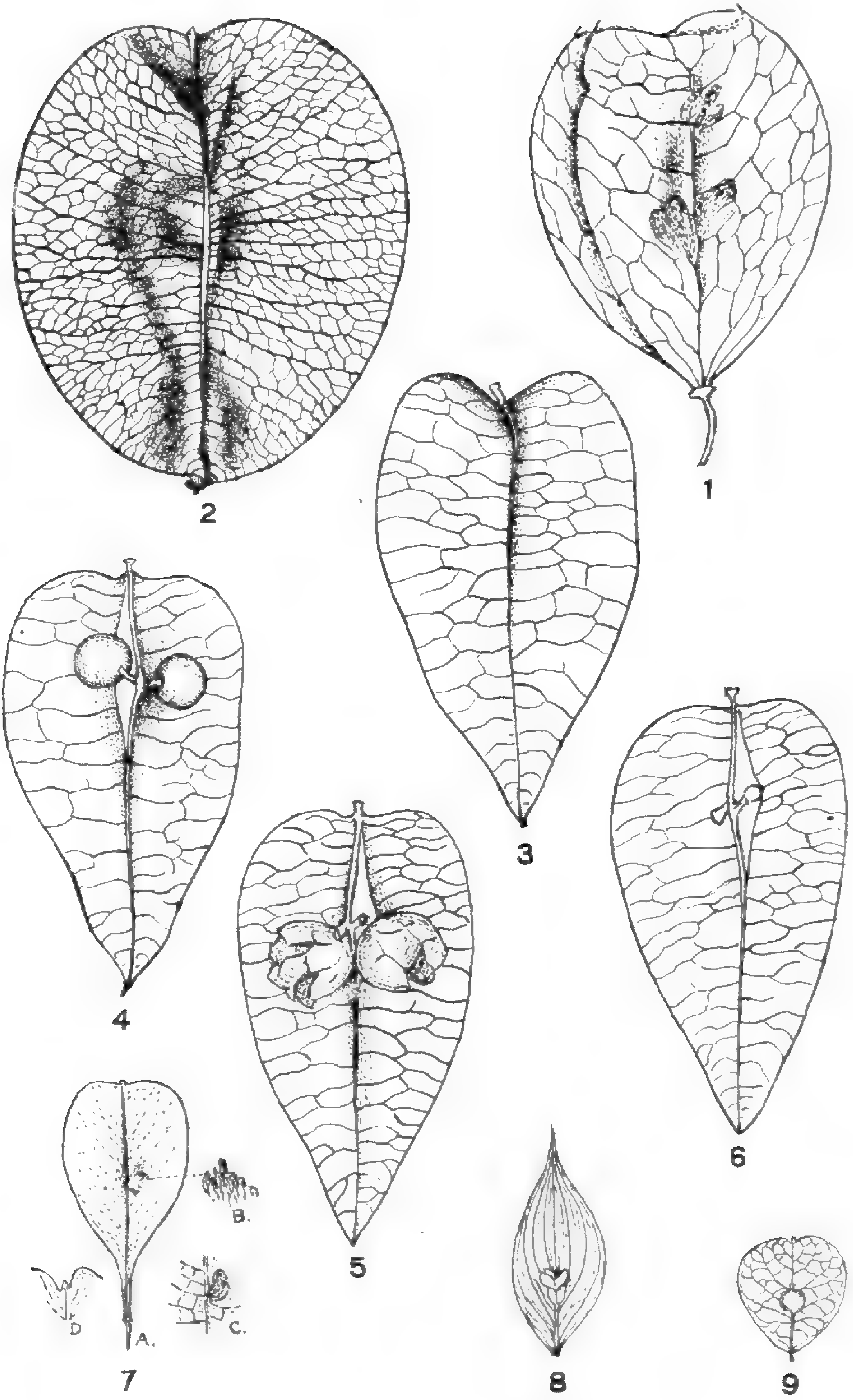


3

1a

3a

HOLLICK: STATUS OF OPHIOGLOSSUM ALLENI



HOLLICK: STATUS OF OPHIOGLOSSUM ALLENI

A note on Penstemon Stephensi

T. S. Brandegee

The reduction of *Penstemon Stephensi* Brandegee to a variety of *P. Clevelandi* Gray has recently been made*, with the mention of a few points of difference and the neglect of an important character, the color of the flowers. *P. Stephensi* is a purple-flowered and *P. Clevelandi* a scarlet-flowered penstemon. Having seen both species alive and growing, I am certain that they have very differently colored flowers and that *P. Stephensi* with its light purple corolla can not represent a color-form of the scarlet *P. Clevelandi*. When a scarlet-flowered species assumes a color-form the flowers become yellow. Some fine specimens of the scarlet-flowered *P. centhranthifolius* Benth., with yellow flowers, grow along the road between Coalinga and Paso Robles, California.

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* See Munz & Johnston, Bull. Torrey Club **49**: 41. 1922.

Two new plants from Colorado

Geo. E. Osterhout

Draba alpicola sp. nov.

A small many-stemmed, perennial, alpine *Draba*; the root-stock much branched, the stems 2–4 cm. high, hispidly pubescent, very slender, carrying one or two leaves, these 5–8 mm. long, scant 2 mm. wide, sessile by a narrow base; root leaves many, oblanceolate, or narrowly spatulate, widest near the top, 1.5 cm. long, about 2 mm. wide near the top, hispid ciliate on the edges, a few similar hairs on the surfaces but no fine pubescence; the inflorescence congested at the ends of the stems, consisting of three to six flowers on pedicels 2–4 mm. long; the sepals ovate, hispid, 2 mm. long, 1 mm. wide; the petals white nearly 4 mm. long, 2 mm. wide at the top, narrowed to a claw; the silique 3–4 mm. long, 2 mm. wide; the style 1 mm. long.

The only specimens I have of this *Draba* were collected July 22, 1903, No. 2842, on the mountains of Estes Park, Larimer County, on the range beyond "Windy Gulch." From the fact that it had a moss clinging about the roots it is very likely that it grew in the shade and shelter of rocks, probably on the western rim of the mountain, where it slopes toward the canyon of the Thompson River. A portion of the type specimen is in the herbarium of the University of Wyoming.

Oreocarya stricta sp. nov.

Perennial, the stem usually single though occasionally two or three from a tap-root, with a cluster of oblanceolate leaves 2–3 cm. long and 1.5–2.5 mm. wide, at the base; the stem 1.5–2.5 dm. long, strict and upright, without branches, hispid with squarrose translucent hairs 2 mm. long, leafy, the leaves alternate, oblanceolate, similar to the basal ones, all of them hispid with coarse hairs and a finer pubescence beneath; the upper third of the stem bearing the racemose inflorescence, the peduncles very short, the upper of two to four flowers and about 1 cm. long, more crowded at the top of the stem; the calyx 4–5 mm. long, becoming 6–8 mm. long in fruit, the lobes narrowly lanceolate, with a midrib, hispid like the leaves; the corolla the length of the calyx, white with a yellow eye (?), the tube and the limb about equal; nutlets four, margined, narrowly ovate or elliptical, rugose on the back, 3.5 mm. long, about 2 mm. wide.

This is a rather slender and upright *Oreocarya*, with a cluster of leaves at the base. In the dried specimens the corolla appears to have a yellow eye. The nutlets are wrinkled somewhat like those of *O. virgata* (Porter) Greene, but the two plants, in other ways, have almost no similarity. It was collected June 21, 1922, No. 6195, on a stony hill, some distance south of the Yampa or Bear River, in Moffat County, along the "Victory Highway." The country is dry, broken, and desert-like.

WINDSOR, COLORADO

INDEX TO AMERICAN BOTANICAL LITERATURE

1920-1922

The aim of this Index is to include all current botanical literature written by Americans, published in America, or based upon American material; the word America being used in the broadest sense.

Reviews, and papers that relate exclusively to foresty, agriculture, horticulture, manufactured products of vegetable origin, or laboratory methods are not included, and no attempt is made to index the literature of bacteriology. An occasional exception is made in favor of some paper appearing in an American periodical which is devoted wholly to botany. Reprints are not mentioned unless they differ from the original in some important particular. If users of the Index will call the attention of the editor to errors or omissions, their kindness will be appreciated.

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Horne, W. T. A phomosis in grape fruit from the Isle of Pines, W[est] I[ndies], with notes on *Diplodia natalensis*. Phytopathology **12:** 414-418. *pl. 26, 27* + *f. 1.* 17 O 1922.

Hovey, E. O. A tree fern of Middle Devonian time. Nat. Hist. **22:** 458–460. O 1922.

Howard, N. O. The control of sap-stain, mold and incipient decay in green wood with special reference to valuable stock. U. S. Dept. Agr. Bull. 1037: 1–55. *f. 1–26.* 19 Au 1922.

Howe, M. A. Two new Lithothamnieae, calcareous Algae, from the lower Miocene of Trinidad, British West Indies. Proc. U. S. Nat. Mus. **62:** 1–3. *pl. 1–4.* 1922.

Howe, M A., & Hollick, A. A new American fossil hepatic. Bull. Torrey Club **49:** 207–210. *f. 1.* 10 Au 1922.

Jungermanniopsis, gen. nov.

Howe, T. D. A preliminary notice concerning the development of the embryo-sac in *Grindelia squarrosa* (Pursh) Dunal. Proc. Nebraska Acad. Sci. **5:** 116. 1922.

Howell, A. B. Agencies which govern the distribution of life. Am. Nat. **56:** 428–438. O 1922.

Hursh, C. R. The relation of temperature and hydrogen-ion concentration to uredinio-spore germination of biologic forms of stem rust of wheat. Phytopathology **12:** 353–361. *f. 1–7.* 11 S 1922.

Hyde, K. C. Anatomy of a gall on *Populus trichocarpa.* Bot. Gaz. **74:** 186–196. *pl. 6.* 16 O 1922.

Hylander, C. J. A preliminary report on the desmids of Connecticut (cont.). Rhodora **24:** 213–224, 236–241. 1922.

Ikeno, S. Studies on the genetics of flower-colors in *Portulaca grandiflora.* Jour. Coll. Agr. Tokyo **8:** 93–133. *pl. 2.* 5 N 1921.

Illick, J. S. The beeches. Am. For. **28:** 546–551. S 1922. [Illust.]

Illick, J. S. Department of Forestry makes white pine survey of northeastern Pennsylvania. For. Leaves **18:** 179–181. D 1922.

Inman, O. L. *Calamagrostis canadensis* and some related species. ·Rhodora **24:** 142–144. 6 S 1922.

Irwin, M. & Weinstein, M. Comparative studies on respiration —XXI. Acid formation and decreased production of CO, due to ethyl alcohol. Am. Jour. Bot. **9:** 277–282. *f. 1, 2.* 12 Jl 1922.

Iyengar, M. O. P., & Narasimhan, M. J. A new species of *Schizonella.* Phytopathology **12:** 435–438. *f. 1–4.* 17 O 1922.

Schizonella colemani, sp. nov., from India.

Jackson, B. D. Two catalogues. Jour. Bot. **60:** 334, 335. N 1922.

One is a catalogue of plants from P. Kalm.

Janchen, E. Bemerkungen zu der Cistaceen-Gattung *Crocanthemum.* Oester. Bot. Zeitschr. **71:** 266–270. D 1922.

Includes *C. stipulatum*, sp. nov., from Texas.

Johnson, J. The relation of air temperature to the mosaic disease of potatoes and other plants. Phytopathology **12**: 438–441. *f. 1.* 17 O 1922.

Johnston, E. S. Moisture content of peach buds in relation to temperature evaluations. Bot. Gaz. **74**: 314–319. *f. 1, 2.* 23 N 1922.

Johnston, I. M. Undescribed plants from Baja California. Univ. California Publ. Bot. **7**: 437–446. 7 Au 1922.

Contains new species in *Ephedra* (1), *Stenophyllus* (1), *Euphorbia* (3), *Securinega* (1), *Cryptantha* (1), and *Houstonia* (1).

Jones, D. F. Selective fertilization and the rate of pollen-tube growth. Biol. Bull. **43**: 167–174. *f. 1, 2.* S 1922.

Jones, L. R., McKinney H. H., & Fellows, H. The influence of soil temperature on potato scab. Agr. Exp. Sta. Univ. Wisconsin Bull. 53: 1–35. *pl. 1–5 + f. 1–9.* Jl 1922.

Jones, L. R., & Tisdale, W. B. The influence of soil temperature upon the development of flax wilt. Phytopathology **12**: 409–413. *f. 1.* 17 O 1922.

Jurica, H. S. A morphological study of the Umbelliferae. Bot. Gaz. **74**: 292–307. *pl. 13, 14.* 23 N 1922.

Karper, R. E. Compound fruits in the peach resulting from multiple pistils. Jour. Hered. **12**: 403–406. *f. 9–11.* 15 Ap 1922.

Kauffman, C. H., & Kerber, H. M. A study of the white heart-rot of locust, caused by *Trametes robiniophila*. Am. Jour. **9**: Bot. 493–508. *f. 1–3.* 27 N 1922.

Kelley, A. P. Plant indicators of soil types. Soil Sci. **13**: 411–423. Je 1922.

Kempton, J. H. Linkage between brachysm and adherence in maize. Am. Nat. **56**: 461–464. O 1922.

Kempton, J. H. Waxy endosperm in *Coix* and *Sorghum*. Jour. Hered. **12**: 396–400. *f. 6.* 15 Ap 1922.

Kennard, F. H. Moulds and bacteria on egg collections. Auk **38**: 345–356. Jl 1921.

Kennedy, P. B. Identification and control of California weeds. Bull. Dept. Agr. California **11:** 11–18. Jl 1922.

Kirchner, O. V. Zur Selbstbestäubung der Orchidaceen. Ber. Deutsch. Bot. Ges. **40:** 317–321. 1922.

Kirkwood, J. E. Forest distribution in the northern Rocky Mountains. Univ. Montana Bull. 247: 1–180., *f. 1–45.* Je 1922.

Kittredge, E. M. *Osmunda Claytoniana* forma *Mackiana.* Am. Fern Jour. **12:** 53–57. *pl. 3,4.* 11 S 1922.

Klaphaak, P. J. & Bartlett, H. H. A preliminary notice of genetical studies of resistance to mildew in *Oenothera.* Am. Jour. Bot. **9:** 446–458. 20 O 1922.

Kneucker, A. Hans Freiherr von Türckheim. Allg. Bot. Zeitschr. **24:** 33–36. 1 Au 1922.

Knowlton, C. H., & Deane, W. Reports on the flora of the Boston district,—XXXVI. Ericaceae. Rhodora **44:** 152–156. 11 S 1922.

Knowlton, F. H. The Laramie flora of the Denver basin. U. S. Geol. Surv. Professional Paper 130: 1–175. *pl. 1 28.* 1922.

With a review of the Laramie problem. Includes many new species.

Korstian, C. F., & Baker, F. S. Is Douglas fir replacing western yellow pine in central Idaho? Jour. For. **20:** 755–764. N 1922.

Kraebel, C. J. Report on experimental forest planting at high altitudes of Maui and Hawaii. Hawaiian For. & Agr. **19:** 151–158. *pl. 1 4.* Jl 1922.

Kränzlin, F. Orchidaceae—Monandrae. Tribus Oncidiinae—Odontoglosseae II. Pflanzenreich IV. **50:** 1–344. *f. 1–29.* 1922.

Includes new species in *Cyrtochilum* (9), *Oncidium* (54), *Leochilus* (2) *Sigmatostalix* (9), *Cryptarrhena* (1).

Krause, K. Contribuicão ao conhecimento das Loranthaceae do Brazil meridional. Anex. Mem. Inst. Butantan [Brazil] Secc. Bot. **1**^{6}**:** 85–92, 97. *pl. 20.* N 1922.

La Rue, C. D. Lightning injury to *Hevea brasiliensis.* Phytopathology **12:** 386–389. 11 S 1922.

La Rue, C. D. The results of selection within pure lines of *Pestalozzia Guepini* Desm. Genetics **7:** 142–201. *f. 1–10.* Mr 1922.

Lehman, S. G. Pod and stem blight of the soybean. Jour. Elisha Mitchell Soc. **38:** 13. S 1922.

Leonian, L. H. Stem and friut blight of peppers caused by *Phytophthora Capsici* sp. nov. Phytopathology **12:** 401–408. *f. 1, 2.* 17 O 1922.

Levine, M. The origin and development of lamellae in *Agaricus campestris* and in certain species of *Coprinus.* Am. Jour. Bot. **9:** 509–533. *pl. 28–35.* 27 N 1922.

Lipman, C. B., & Taylor, J. K. Proof of the power of the wheat plant to fix atmospheric nitrogen. Science II. **56:** 605, 606. 44 N 1922.

Long, B. *Sonchus uliginosus* occurring in the Philadelphia area. Torreya **22:** 91–98. D 1922.

Long, C. A. E. Notable additions to the flora of Knox Co., Maine. Rhodora **24:** 181–183. 27 S. 1922.

Lyon, H. L. Hawaiian forests. Hawaiian For. & Agr. **19:** 159–162. Jl 1922.

MacInnes, J. The growth of the wheat-scab organism in relation to hydrogen-ion concentration. Phytopathology **12:** 290–294. *f. 1.* 12 Au 1922.

Mackenzie, K. K. The records for *Limnobium Spongia* in the northern United States. Torreya **42:** 102–104. D 1922.

Mackenzie, K. K. *Viburnum cassinoides.* Addisonia **7:** 17. *pl.* 233. 25 S 1922.

Maldonado, A. & E. Contribucion al estudio de los productos vegetales que se encuentran en los "restos de cocina" precolombinos de Tambo Inga. [Peru]. Arch. Asoc. Peruana Prog. Cien. **1:** 118–130. *pl. 13–19.* 1921.

Malme, G. O. A: N. Die Juncazeen der zweiten Regnellschen Reise. Arkiv Bot. **18^4:** 1–6. 8 Au 1922.

Maneval, W. E. Germination of teliospores of rusts at Columbia, Missouri. Phytopathology **12:** 471–488. 5 D 1922.

Matsumato, T. Some experiments with azuki-bean mosaic. Phytopathology **12:** 295–297. 12 Au 1922.

Mattoon, W. R. Longleaf pine. U. S. Dept. Agr. Bull. 1061: 1–50. *pl. 1–22 + f. 1–6.* 29 Jl 1922.

Pinus palustris Mill.

Maxon, W. R. Ferns new to the Cuban flora. Jour. Washington Acad. Sci. **12:** 437–443. 19 N 1922.

Includes 4 new species.

Maxon, W. R. The genus *Culcita.* Jour. Washington Acad. Sci. **12:** 454–460. 4 D 1922.

Maxon, W. R. A new *Salvinia* from Trinidad. Jour. Washington Acad. Sci. **12:** 400, 401. 19 O 1922.

Maxon, W. R. Studies of Tropical American ferns—VII. Contr. U. S. Nat. Herb. **24:** 33–63. *pl. 11–20.* 1922.

Includes *Atalopteris,* gen. nov., and new species in *Alsophila*(6) *Dicranopteris* (1), *Cheilanthes* (2), *Polystichum* (2), *Dryopteris* (3).

Mell, C. D. The early uses of the yaupon. Am. For. **28:** 351. S 1922.

Ilex vomitoria Ait.

Mendiola, N. B. Effect of different rates of transpiration on the dry weight and ash content of the tobacco plant. Philipp. Jour. Sci. **20:** 639–655. Je 1922.

Merrill, E. D. A bibliographic enumeration of Bornean plants. Jour. Straits Br. Roy. Asiatic Soc. **9:** 1–592. 1921.

Merrill, E. D. Diagnoses of Hainan plants. Philipp. Jour. Sci. **21:** 337–355. O 1922.

Merrill, E. D. Notes on the flora of southeastern China. Philipp. Jour. Sci. **21:** 491–512. N 1922.

Merrill, E. D. Additions to our knowledge of the Bornean flora. Philipp. Jour. Sci. **21:** 515–534. D 1922.

Merrill, E. D. Two new species of plants from Hainan. Philipp. Jour. Sci. 39: 677–679. D 1921.

Merriman, M. L. A new species of *Spirogyra* with unusual arrangement of the chromatophores. Am. Jour. Bot. **9**: 283, 284. *f. 1–3.* 12 Jl 1922.

Spirogyra rectispira, sp. nov., from New York.

Metcalf, F. P. Notes on marsh and aquatic plants of Missouri. Jour. Washington Acad. Sci. **12**: 307–312. 19 Jl 1922.

Milbraith, D. G. *Alternaria* from California. Bot. Gaz. **74**: 320–324. *f. 1, 2.* 23 N 1922.

Alternaria oleracea sp. nov.

Montoya y Plorez, J. B. Titiribies y sinufanaes. Pp. 1–60. Medellin, Colombia. 1922.

Moss, E. H. Observations on two poplar cankers in Ontario. Phytopathology **12**: 425–427. 17 O 1922.

Mousley, H. Further notes on the ferns of Hatley, Stanstead County, Quebec, 1921–1922. Canad. Field-Nat. **36**: 149–152. 4 O 1922.

Muenscher, W. C. The effect of transpiration on the absorption of salt by plants. Am. Jour. Bot. **9**: 311–329. 12 Jl 1922.

Munns, E. N. Bear clover and forest reproduction. Jour. For. **20**: 745–754. *f. 1–3.* N 1922.

Munz, P. A., & Johnston, I. M. The distribution of southern California Pteridophytes (cont.). Am. Fern Jour. **12**: 101–122. 30 D 1922.

Murrill, W. A. Dark-spored agarics—IV. *Deconica, Atylospora* and *Psathyrella.* Mycologia **14**: 258–278. 1 S 1922.

Includes 8 new species.

Nagai, I. A genetico-physiological study on the formation of anthocyanin and brown pigments in plants. Jour. Coll. Agr. Tokyo **8**: 1–92. *pl. 1.* 5 N 1921.

Nelson, J. C. Additions to the flora of western Oregon during 1921. Torreya **22**: 98–102. D 1922.

Nelson, J. C. The bracken as a poisonous plant. Am. Fern Jour. **12**: 125–127. 30 D 1922.

Nelson, J. C. *Muscari comosum* in Oregon. Rhodora **24**: 208–210. 6 O 1922.

Nelson, J. C. A new weed from Oregon. Torreya **22**: 86–88. O 1922.

Salvia Aethiopis L.

Nevermann, F. Das Balsaholz. Tropenpflanzer **25**: 49–52. Ap 1922.

Newton, R., & Gortner, R. A. A method for estimating hydrophilic colloid content of expressed plant tissue fluids. Bot. Gaz. **74**: 442–446. 21 D 1922.

Osterhout, G. E. Two new plants from western Colorado. Bull. Torrey Club **49**: 183, 184. 8 Jl 1922.

Nuttallia marginata and *Acrolasia humilis*, spp. nov.

Overholts, L. O. Mycological notes for 1920. Bull. Torrey Club **49**: 163–173. *pl. 9 + f. 1–14.* 8 Jl 1922.

Pammel, L. H., & Cratty, R. I. Notes on some plants of the Arapahoe National Forest and Rocky Mountain National Park [Colorado]. Proc. Iowa Acad. Sci. **27**: 51–73. *f. 1–9.* 1920.

Pammel, L. H., & King, C. M. The germination of some trees and shrubs and their juvenile forms. Proc. Iowa Acad. Sci. **27**: 75–80. *f. 10, 11.* 1920.

Parlin, J. C. *Waldsteinia* in Maine. Rhodora **24**: 124. 28 Au 1922.

Parodi, L. R. Las gramineas de la region de Concordia [Argentina]. Rev. Facult. Agron. y Veter. Univ. Nac. Buenos Aires **4**: 24–101. *f. 1–4.* 1922.

Pearl, R. Trends of modern biology. Science II **56**: 581–592. 24 N 1922.

Pearson, W. H. West Indian Hepaticae. Jour. Bot. **60**: 217–228. 1922.

Includes 3 new species.

Peck, M. E. The vegetation of Cape Blanco [Oregon]. Proc. Iowa Acad. Sci. **27**: 85–89. 1920.

Pennell, F. W. Some overlooked Scrophulariaceae of Rafinesque. Torreya **22**: 77–84. O 1922.

Pfeiffer, N. E. Monograph of the Isoetaceae. Ann. Missouri Bot. Gard. **9**: 79–232. *pl. 12–19.* Ap 1922.

Includes 3 new American species.

Poole, R. F. A new fruit rot of tomatoes. Bot. Gaz. **74**: 210–214. *pl. 7.* 16 O 1922.

Poponoe, W. Dr. Fenzi's contributions to American horticulture. Jour. Hered. **13**: 215–220. 12 D 1922. [Illust.]

Poponoe, W., & Pachano, A. The capulin cherry. Jour. Hered. **13**: 51–62. 7 S 1922. [Illust.]

A cultivated form of *Prunus serotina* Ehrh.

Porterfield, W. M. References to the algae in the Chinese classics. Bull. Torrey Club **49**: 297–300. *f. 1.* 11 O 1922.

Ramsey, G. B. *Basisporium gallarum* Moll., a parasite of the tomato. Bot. Gaz. **74**: 325–328. *f. 1–11.* 23 N 1922.

Rangel, E. *Oswaldia icarahyensis* (nota preliminar). Revista Sci. **4**: 93, 94. *f. 1–4.* Je 1922.

A new genus from Brazil.

Rankin, W. H., & Hockey, J. F. Mosaic and leafcurl (yellows) of the cultivated red raspberry. Phytopathology **12**: 253–264. 12 Au 1922.

Rehder, A. New species, varieties and combinations from the herbarium and the collections of the Arnold Arboretum (cont.). Jour. Arnold Arb. **3**: 207–224. D 1922.

Rehder, A. Two new Asiatic poplars. Jour. Arnold Arb. **3**: 225–227. D 1922.

Reid, E. M. Age and area from a palaeobotanical standpoint. In Willis, J. C., Age and area 137–147. 1922.

Richmond, I. J. A. N. Jones—plant breeder. Jour. Hered. **13**: 103–107. 30 S 1922.

Rigg, G. B. A bog forest. Ecology **3**: 207–213. *f. 1, 2.* Jl 1922.

Riko, B. P. Nutz-und Edelhölzer Mexicos. Tropenpflanzer **25**: 16–22, 52–56. F 1922.

Rimbach, A. Lebensweise von *Chloraea membranacea*. Ber. Deutsch. Bot. Ges. **40**: 322–326. *f. 1–6.* 1922.

Robbins, R. B. Selection through the choice of seeds from dominant plants of an allogamous population. Genetics **7**: 508–512. S 1922.

Robbins, W. J. Effect of autolized yeast and peptone on growth of excised corn root tips in the dark. Bot. Gaz. **74**: 59–79. *f. 1–8.* 15 S 1922.

Roberts, R. H. The development and winter injury of cherry blossom buds. Wisconsin Agr. Exp. Sta. Bull. 53: 1–24. *pl. 1–4 + f. 1–7.* Jl 1922.

Robinson, B. L. The mikanias of northern and western South America. Contrib. Gray Herb. **64**: 21 116. 18 Ap 1922.

Robinson, B. L. Records preliminary to a general treatment of the Eupatorieae—I. Contrib. Gray Herb. **64**: 3–21. 18 Ap 1922.

Includes new species in *Ageratum* (1) and *Mikania* (17).

Rose, J. N. *Byrnesia; Weinbergii.* Addisonia **7**: 37, 38. *pl. 243.* 4 D 1922.

New genus of uncertain fatherland.

Rose, J. N. *Echinocereus Baileyi.* Addisonia **7**: 41. *pl. 245.* 4 D 1922.

Rose, J. N. *Graptopetalum pachyphyllum.* Addisonia **7**: 45. *pl. 247.* 4 D 1922.

New species from Mexico.

Rose, J. N. *Runyonia longiflora.* Addisonia **7**: 39, 40. *pl. 244.* 4 D 1922.

New genus and species from southern Texas.

Round, E. M. A modern plant fossil. Bull. Torrey Club **49**: 63, 64. *f. 1.* 12 Ap 1922.

Rowlee, W. W. The genus *Costus* in Central America. Bull. Torrey Club **49**: 283–292. *pl. 12–15.* 11 O 1922.

Rudolfs, W. Effect of seeds upon hydrogen-ion concentration of solutions. Bot. Gaz. **74**: 215–220. 16 O 1922.

Rugg, H. G. *Adiantum pedatum* var. *aleuticum* in New England. Am. Fern Jour. **12**: 128–130. *pl. 8.* 30 D 1922.

Rusby, H. H. New species of trees of medical interest from Bolivia. Bull. Torrey Club **49**: 259–264. 22 S 1922.

Includes new species in *Nectandra* (1), *Ocotea*(1), *Aerodiclidium* (1), and *Guarea* (2).

Rusby, H. H. Report of work on the Mulford Biological exploration of 1921–22. Jour. New York Bot. Gard. **23**: 101–112. Au 1922.

Exploration in Bolivia and Brazil.

Rusk, H. M. *Lilium Warleyense.* Addisonia **7**: 57, 58. *pl. 253.* 30 D 1922.

Rydberg, P. A. Ambrosiaceae. N. Am. Fl. **33**: 3–44. 15 S 1922.

Includes *Leuciva, Chorisiva, Acanthambrosia,* gen.nov., and 18 new species.

Rydberg, P. A. Carduaceae. N. Am. Fl. **33**: 45, 46. 15 S 1922.

Rydberg, P. A. Carduales. N. Am. Fl. **33**: 1. 15 S 1922.

Sargent, C. S. Notes on North American trees, IX. Jour. Arnold Arb. **3**: 1–11. Jl 1921.

Includes 11 new species of *Crataegus.*

Sargent, C. S. Notes on North American trees, X. Jour. Arnold Arb. **3**: 182–207. D 1922.

Includes 25 new species of *Crataegus.*

Schaffner, J. H. The sexual nature of vegetative or dichotomous twins in *Arisaema.* Ohio Jour. Sci. **22**: 149–154. Ap 1922.

Schenck, H. Vegetationsbilder aus der Sierra de Mixteca, Mexico. Vegetationsbilder **14**: *pl. 25–36* with text. 1922.

Schmitz, H. Note concerning the decay of western yellow pine slash caused by *Polyporus volvatus* Peck. Phytopathology **12**: 494–496. *f. 1.* 5 D 1922.

Sears, P. B. Variations in cytology and gross morphology of *Taraxacum.* Bot. Gaz. **73**: 308–325. *pl. 9, 10.* 15 Ap 1922; 425–446. *f. 1–9.* 17 Je 1922.

Seaver, F. J. Some edible cup-fungi. Jour. New York Bot. Gard. **23**: 112–115. *pl. 274.* Au 1922.

Seaver, F. J. Phyllostictales. Phyllostictaceae (pars). N. Am. Fl. **6**: 1–84. 5 Ap 1922.

Includes 2 new species.

Seaver, F. J. Studies in tropical American Ascomycetes—I. Mycologia **14**: 235–238. *pl. 19.* 1 S 1922.

Seckt, H. Estudios hidrobiologicos en la Argentina. Schizophyceae. Bol. Acad. Nac. Ci. Cordoba **25**: 383–429. *f. 1–47.* 1922.

Includes new species in *Lyngbya* (2), *Anabaena* (2), *Homeothrix* (1).

Seward, A. C. On a collection of Carboniferous plants from Peru. Jour. Geol. Soc. **78**: 278–284., *pl. 13.* 23 S 1922.

Seward, A. C. A study in contrasts: the present and past distribution of certain ferns. Jour. Linnean Soc. **46**: 219–240. *pl. 16–19.* 20 O 1922.

Shaw, W. R. *Janetosphaera*, a new genus, and two new species of *Volvox.* Philipp. Jour. Sci. **20**: 477–508. *pl. 1–5 + f. 1–5.* My 1922.

Shaw, W. R. *Merrillosphaera*, a new genus of the Volvocaceae. Philipp. Jour. Sci. **21**: 87–129. *pl. 1–7 + f. 1.* Jl 1922.

Shear, C. L. Life history of an undescribed ascomycete isolated from a granular mycetoma of man. Mycologia **14**: 239–243. *f. 1–3.* 1 S 1922.

Describes *Allescheria Boydii* sp. nov.

Shelford, V. E., & Gail, F. W. A study of light penetration into sea water made with the Kunz photo-electric cell with particular reference to the distribution of plants. Publ. Puget Sound Biol. Sta. **3**: 141–176. *pl. 24–30.* 20 D 1922.

Vol. 50 No. 7

BULLETIN

OF THE

TORREY BOTANICAL CLUB

JULY, 1923

Studies on plant cancers—IV. The effects of inoculating various quantities of different dilutions of Bacterium tumefaciens into the tobacco plant*

MICHAEL LEVINE

The early studies of dosage center about the question of the transmission of tuberculosis and date back to the period shortly before the discovery of tubercle bacilli. Tappeiner (1878–1880) was among the first to test the effect of crudely measured quantities, such as a teaspoonful and a tablespoonful, of sputum of a tubercular patient sprayed into the respiratory tract of a dog. In 1890, Gebhardt, under favorable and aseptic conditions, studied the effect of inhalations of tubercle bacilli and also intraperitoneal and subcutaneous injections of the same organism into the guinea pig. He used the expressed milk of the udder of tubercular cows, the sputum of phthisis patients, and pure cultures of the bacillus grown on beef-peptone-glycerine. With the pure cultures he used 5 cmm. to 2 cc. sterile water. This suspension was diluted 1 : 400 and used as a mother liquor. Intraperitoneal injection of a dilution of the mother liquor in a proportion of 1 : 500 gave tuberculosis. Very dilute suspensions induced tuberculosis by inhalation and subcutaneous injections. Preyss (1891) made a more determined effort to establish the quantity of tubercle bacilli necessary to cause tuberculosis. He found that a droplet 1/1000 mg. of sputum which contains forty tubercle bacilli was sufficient to induce tuberculosis in the guinea pig. He made no actual count of this number but estimated it on the basis of 1 mg. moist culture of tubercle bacilli, which he claimed contained thirty-five million organisms.

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* From the Cancer Division, Montefiore Hospital, Dr. Isaac Levin, Chief.

[The BULLETIN for June (**50**: 197–230. *pl. 9–12*) was issued July 6, 1923.]

Huytra (1905), in studying the effect of von Behring's inoculating fluid in immunizing cattle against Bovine tuberculosis, used 0.004–0.025 gm. of Bovine tuberculosis to produce this disease. Findel (1907) studied the difference between inhalation and feeding as methods for inducing tuberculosis. He used dogs, calves and guinea pigs. Like Preyss he calculated that by certain spray methods he was able to induce tuberculosis in the guinea pig with twenty tubercle bacilli and suggests that only one bacillus is sufficient to infect the guinea pig. Theobald Smith (1908) in studying Bovine tuberculosis, immunized cattle by injections of 5–300 mg. of dry weight of tubercle bacilli of the human of different ages. The number of individuals in these masses of bacteria was not estimated.

Barber (1907), studying the transmission of the characters, size, and form in *Saccharomyces anomalus*, *Bacillus coli communis*, *B. typhosus* and *B. megatherium*, devised an isolation pipette whereby he was able to make a culture from a single cell. By this method he was also able to inoculate a mouse with three to six bacilli of anthrax obtained from the blood of another mouse with this disease. Webb, Williams and Barber (1909) studied the method of immunizing an animal against a specific disease by inoculating the animal with small doses of bacteria, beginning with a single cell and then increasing the number. In this work the isolation pipette was used so that the cells were seen, counted and then inoculated. This was done for typhoid, anthrax and tuberculosis.

Wyssoskowicz (see Adami, 1908, p. 185) claimed that the minimal dose required to induce tuberculosis in guinea pigs was eight tubercle bacilli; while twenty-four to thirty were required for the rabbit.

A voluminous literature dealing with the effects of measured doses of inoculum in animals has developed in the last two decades, but these studies were made in connection with work in immunity, distribution of parasites, etc., and with no special reference to the question under consideration here.

While I have been unable to find in the literature any reference to dosage studies with bacterial parasites of plants, Cobb (1904–1905) suggested that the degree of infection of a crop of wheat with smut could be determined by counting the number of smut spores that could be removed from the seed samples.

He washed seed samples and calculated the spore content of the washings by counting the spores of a given quantity of washings against red blood cells. While Cobb was the first to count spores of parasitic diseases of plants Bolley (1902) first suggested the use of the centrifuge in removing the spores from seeds for microscopic determination. Heald (1921) took up the work of Bolley and Cobb and devised new methods for calculating the number of spores of smut per wheat grain. He planted seeds with a known spore number and then estimated the degree of smutting in the crop. Heald also infected wheat with known quantities of smut spores and determined the degree of infection in the crop. For example, he determined that 0.5—3 gm. of air dry spores per hundred wheat grains gave maximum smutting. Heald contends that there seems to be a gradual increase in the percentage of smut in a crop with an increase in the number of spores carried by each grain. He does not believe that infection of wheat with bunt can be accomplished by a single spore.

My earlier studies on crown gall in sugar beets (Levine, 1921) dealing with the effect of soil conditions on the health of the host and the size of the crown gall produced by inoculation have led me naturally to the problem of what the quantity of bacteria used in the inoculum has to do with the size of the crown gall. This study was started simultaneously with the study of the effect of soil conditions on the size of the crown gall in 1920 and was continued in the following year, 1921. While the results are not complete, the data obtained so far, seem to be of sufficient interest to warrant this report.

METHODS

During the month of May 350 tobacco seedlings sent from Virginia, varying in height from 6 to 10 inches, were set out in uniformly treated soil under similar light and moisture conditions. Toward the latter part of July and early August the plants were inoculated with *Bacterium tumefaciens*. Eight different emulsions of four different ages were used as inocula. These cultures were grown under uniform laboratory conditions and on a medium which consisted of 50 gm. beans, 1 l. water, 15–20 gm. agar agar. Enough of the medium was poured into 150 cc. Erlenmeyer flasks to cover the bottom to a depth of 1 cm. The medium was then inoculated by pricking the surface of the agar in five to eight different places with a needle containing a subculture of *Bacterium tumefaciens.* After the bacteria had multiplied for from two to forty days the surface of the agar was gently scraped to avoid as far as possible the removal of portions of the surface of the agar. I employed two methods for inoculating my plants. The first, a modified form of the commonly used pricking method, and the second, the trocar method. In the first method the cylinder of a medium-sized hypodermic needle was filled with paraffin so as to convert the point into a spoon-like container. This was dipped (into an emulsion of *B. tumefaciens*), so that the spoon end of the needle alone contained the bacteria. This was then gently stuck into the plant at a desired point, five to ten times, until all the emulsion was removed into the plant. For larger measured quantities of bacteria the second method was used. A plug of tissue 3-5 mm. long and 0.5 mm. in diameter was removed from the part of the plant where the inoculation was to be made by a trocar. The suspension of the crown gall organism was then introduced through a graduated hypodermic syringe. Numerous controls were made by removing a plug of tissue and filling the cavity with sterile water.

All mother emulsions consisted of 4 cc. of such culture scrapings of *B. tumefaciens,* to which was added 2 cc. of sterile water to facilitate the removal of the bacteria from the surface of the agar. The following dilutions of these cultures were made and will be referred to in the text by number.

Emulsion Ia is from a culture of *Bacterium tumefaciens* 21 days old. Subdilutions of this culture were made by the addition of sterile water in the following proportions: *Ib,* 1 : 1; *Ic,* 1 : 10; *Id,* 1 : 20.

Emulsion IIa is from another set of cultures of *Bacterium tumefaciens* 21 days old. *IIb* consisted of a part of the emulsion, *IIa,* diluted with an equal part of sterile water. In *IIc,* the dilution was made in the ratio 1 : 3.

Emulsion IIIa is from a third group of cultures grown at another later period used at the age of 21 days. In *IIIb,* the dilution is made in the proportion 1 : 5; in *IIIc,* 1 : 10; in *IIId,* 1 : 15; in *IIIe,* 1 : 25.

Emulsion IV represents still another set of cultures 21 days old. This was used undiluted.

Emulsion V is from cultures of *Bacterium tumefaciens* 40 days old.

Emulsion VIa is an emulsion from young cultures 2 days old. *VIb* was diluted 1 : 15; *VIc,* 1 : 10; *VId,* 1 : 20; *VIe,* 1 : 40.

Emulsion VII is an undiluted mother emulsion seven days old.

In the latter part of October harvesting began. The plantation had been plotted for identification of the test plants early in the season. Each test plant was now carefully removed from the soil. The diameters of the more globular crown galls were measured in several axes, averaged and recorded. The averages of these measurements for a number of plants are shown in the TABLE below. Leafy crown galls and axillary leafy crown galls were also measured although obvious difficulties were met in doing this.

OBSERVATIONS

While to actually count the number of *Bacterium tumefaciens* inoculated in a given case was impossible yet dilutions of emulsions of the organisms sufficiently different were used to show contrasted effects, if any be produced in this way. In 1920, two hundred midveins of sixty well grown tobacco plants were inoculated with dilutions of *Bacterium tumefaciens* from culture fourteen days old. The dilutions were made in the following proportions: A, 1 : 100; B, 1 : 50; C, 1 : 25; D, 1 : 15; E, 1 : 2; and F, 1 : 1. The crown galls which resulted were all approximately the same size. Each intumescence measured approximately 0.2–0.3 cm. in diameter. These results were followed up by further studies in 1921. The TABLE shows the results. In general, they confirm the preliminary studies. In these later studies the stems were also inoculated at the node and internode as mentioned below.

Emulsion Ia was made by collecting 4 cc. of scrapings from a flask culture of *Bacterium tumefaciens* and diluting as noted above. Dilution Ib consisted of 1 cc. of the emulsion mixed with an equal part of sterile water. Dilution Ic was mixed in proportion of 1 : 10 parts of water; Id, 1 : 20; and Ie, 1 : 30. Forty-seven plants of uniform size and age and growing in the same plot were inoculated with one drop of Emulsion Ia, b, c, d, and e, of *Bacterium tumefaciens* in trocar incisions made in the axils of the upper leaves. The size of the crown galls was measured at the end of the season and found to be more or less uniform, varying within the range of the variation in size found in the individual plants. Dilution Ia inoculated into twenty-two plants by the trocar method gave an average size crown gall 1.8 cm. in diameter. While Id and Ic, dilutions ten to twenty times weaker, gave an average size crown gall slightly larger. Id gave approximately the same results as Ib (see TABLE).

When the axil of an upper leaf of a decapitated plant was similarly treated, the average size of the crown gall for the four

AVERAGE SIZE ** OF CROWN GALL ON TOBACCO RESULTING FROM INOCULATIONS WITH VARIOUS EMULSIONS OF BACTERIUM TUMEFACIENS

Emulsions and dilutions	Character and quantity	Age of culture	No. of plants	Mid-vein leaf	No. of plants	Stem	No. of plants	Leaf axil	No. of plants	Leaf axil of decapitated plants
No. I										
a	1 drop trocar method	21 days			5	1.5	22	1.8	10	2.3
b							10	2.2	9	1.9
c							7	2.3	8	2.3
d							8	1.9	10	2.7
d^{1}	0.8 cc.*						20	1.9		
No. II										
a	1 drop 5–10 needle pricks	21 days					11		1.2	
b							9		1.3	
c							12		1.5	
a^{1}	1 drop trocar method						12		1.9	
c^{1}							16		2.3	
No. III										
a	1 drop trocar method	21 days	5	0.3	5	1.6				
b			5	0.3	5	1.06				
c			5	0.3	5	0.6				
d					5	2.3				
e					5	1.8				
No. IV	1 drop 5–10 needle pricks	21 days	6	0.9						
No. V	1 drop 5–10 needle pricks	40 days	6	0.5						
No. VI										
a	1 drop trocar method	2 days			5	1.6			4	2.1
b					5	2.2			13	1.5
c					5	2.			14	3.2
d					5	2.6			4	1.6
e					5	3.1			4	3.5
a^{1}	0.25 cc.*						16	2.7		
No. VII	trocar method									
a	0.28 cc.*	7 days	15	0.7						
b	0.5 cc.*		11	1.2						

* Average quantity.
** Size given in cm.

dilutions used was more or less uniform. The average size of the crown gall produced by dilution Ic was 2.3 cm. while Id (in which the suspension was 1 : 20) gave a crown gall which averaged 2.7 cm. in diameter. The same general results were obtained with dilutions of Emulsion VI (see TABLE) when inoculated into the stem and leaf axils of decapitated plants by the trocar method. Here in the thirty-nine plants studied, the largest crown galls were produced with the weakest suspension, 6e. Yet the variations were slight and if a sufficient number of cases had been available, it is believed the average size of the crown galls would probably have been more nearly alike. The fact still remains, however, that the smallest crown galls were produced with suspensions bearing the largest number of bacteria.

The inoculation of the upper axillary buds of decapitated stems showed that 6c and 6e gave results more than double those of 6b and 6d, respectively. The dilution in each case was half the strength of those that gave the smaller growths.

Inoculating the midveins of leaves with the dilutions of Emulsion III listed above, gave more consistent and uniform results. In fifteen plants so studied the average diameter of the crown galls was 0.3 cm. The inoculations of the stem gave quite a range in size of the galls produced, but here again as shown for the other two series the number of bacteria did not obviously influence the size of the growths. The sizes of the crown galls seemed to be correlated with the individual variations in the sizes of the plants, but here again emulsion dilution 3d (1 : 15) gave crown galls almost twice as large as those obtained with 3a, which is the mother emulsion.

Inoculating these plants by pricking them with a needle capable of holding a uniform quantity of bacteria gave approximately equal results, which shows that the number of bacteria or strength of the emulsion within the range tested is not directly concerned with the size of the crown gall. Emulsion II was used in inoculating thirty-two plants by dipping the point or spoon-like end of a filled hypodermic needle into emulsion IIa, b ,and c of *Bacterium tumefaciens*, and then pricking the plant with the point of the needle. The inoculated plants showed at the end of the growing season that the more concentrated suspension of *Bacterium tumefaciens* did not produce the largest gall. As it happened, it produced the smallest.

Comparing the trocar and the needle method of inoculation as used, cultures IIa and IIc—IIa′ and IIc′ (the latter two cultures indicate similar dilutions but used with the trocar) show somewhat larger galls for the trocar method. The differences, however, do not appear to be significant. The weak dilution produced growths which averaged 0.4 cm. larger than the dilution which was three times the strength of the first. It seems from these studies that for uniformly aged cultures and equally well developed plants a drop of the weakest suspension used when inoculated into the stem or midvein of a tobacco plant incites a crown gall development as large as a suspension forty times more concentrated.*

COMPARISON OF THE REACTIONS OF DIFFERENT PARTS OF THE PLANT TO EQUAL QUANTITIES OF THE SAME DILUTION

Striking differences were found among the crown galls resulting from inoculations with equal quantities of the same or similar dilutions of *Bacterium tumefaciens* when placed in different parts of the plant. This appeared to be true regardless of the quantities of bacteria or strength of the emulsion used. The crown galls on the midveins of leaves were invariably smaller than those on the stem and these in turn were smaller than those that developed at the axil of a leaf. The inoculated axillary bud of a decapitated plant produced generally the largest crown gall.

For example, the sizes of crown galls obtained with Emulsion III a, b, and c on the leaf vein and the stem show that equal quantities of bacteria produce in the stem a neoplastic growth considerably larger than on the midvein of the leaf. Comparing the tumor growths in the leaf axils with those of the stem internode produced by equal quantities of the same emulsion (see TABLE, Emulsion I) shows a slightly larger growth in the axil. The inoculation of Emulsion Ia into five stem internodes pro-

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* Since the above data went to the press I had the opportunity to study further, weaker suspensions of *Bacterium tumefaciens* and the effect of inoculations of one drop and 0.5 cc. of these solutions at the leaf axils of young geranium plants. I used 3 cc. of the scrapings of a twelve day culture of *Bacterium tumefaciens* and suspended 1 cc. in 500, 750, and 1000 cc. of sterilized tap water.

The plants which received 1 drop or 0.5 cc. of the 1:500 solution produced small crown galls which averaged 4 mm. in diameter forty-five days after the inoculation. The plants which received 1:750 and 1:1000 solution, in only a very small percentage of inoculations, were crown galls produced. Those that developed were approximately 3–4 mm. in diameter, and in general, were equal in size to those produced by inoculations with undiluted *Bacterium tumefaciens*.

duced crown galls which averaged 1.5 cm. while inoculation in the axils with similar quantities of the same emulsion gave an average growth 1.8 cm. for twenty-two plants. The result here really suggests a summation of the stimulus from the bacterial organism and the natural budding tendencies of the tissues in the leaf axil if indeed, there is not an actual bud with more or less active growth tendencies in the axil of every leaf.

When the size of the crown gall in the axil of a leaf of a normal plant is compared with that in the axil of a leaf of a decapitated plant it is found that the axillary crown gall is larger (see TABLE Emulsion I). A comparison of the size of the crown galls on stem internodes with those in the axillary buds of decapitated stems produced in each case by equal quantities of the same dilution shows much larger crown galls for the decapitated plants; (study TABLE, Emulsion IV). It appears that the size of the galls produced by equal quantities of similar or identical suspensions of *Bacterium tumefaciens* inoculated depends upon the location of the inoculation. The midvein of a leaf shows the smallest crown gall reaction; while the axil of a leaf of a decapitated stem shows the largest growth. This was of course already implied in the general comparison of galls from different parts of plants.

RELATIVE VIRULENCE

It is a well recognized fact in general old cultures of pathogenic bacteria are less virulent than young cultures. The cultures used in these experiments were subcultures of *Bacterium tumefaciens* (hop strain) sent to this laboratory by E. F. Smith in 1917. These had been kept in culture and used in my former experiments. When the present experiments were started cultures varying from two to one hundred and ninety days old were available. The latter were too dry to warrant any attempt at use. Cultures two days old were made up into various dilutions (Emulsion VI) of which 6a is the undiluted culture drived by scraping the media upon which the organisms were growing. The crown galls which resulted from inoculating the stem internode with this culture showed an average of 1.6 cm. in diameter. Emulsion 3a which is an undiluted culture of *Bacterium tumefaciens* twenty-one days old grown under the same conditions as Emulsion VI also gave crown galls of an average diameter of 1.6

cm. But when these results are contrasted with crown galls resulting from Emulsion 1a, another culture twenty-one days old, the growths resulting from the younger cultures are seen to be slightly larger. Comparing the size of the crown galls in axillary buds the young cultures and the old produced results almost identical; (compare Emulsions I and VI). Cultures twenty-one and forty days old were contrasted by inoculating Emulsions 4 and 5 into midveins of leaves. The larger growths appeared on the leaves which were inoculated with the younger bacteria. Yet the inoculation of Emulsion V in the midvein of the tobacco leaf produced a larger growth than did Emulsion III, another culture twenty-one days old. It appears that so long as the *Bacterium tumefaciens* is viable the age of the culture has little effect on the size on the gall produced. A culture two days old is no more effective in producing crown galls in tobacco than are cultures three to five weeks old.

THE EFFECTS OF VARIOUS QUANTITIES OF SIMILAR DILUTIONS

The size of galls produced when different quantities of similar dilutions of *Bacterium tumefaciens* were inoculated in the tobacco was compared. Comparing results with the prick and the trocar methods it seems that inoculation through a trocar wound produces a slightly larger growth than is produced by pricking the plant five to ten times with a needle carrying an emulsion of the same dilution; (compare 2a and 2a′). The difference may be explained, however, not on the basis of the quantities of the bacteria introduced, but on the degree of injury to the cells caused by the trocar method as compared with the pricking method.

When two different quantities of *Bacterium tumefaciens* were inoculated by the same method the difference in results was negligible. One drop of emulsion Id and 0.8 cc. of the same emulsion called Id′ (for convenience of record) were inoculated into axillary buds of the tobacco. Similar results were obtained. The average size of the crown gall in each series of experiments was 1.9 cm. Sixteen plants were inoculated in the leaf axils with an average dosage of 0.25 cc. of emulsion 6a′ (an emulsion equal to 6a in strength). While these results were not compared with those obtained by using a drop of 6a in the leaf axil it was found that the average size of the growths with 0.25 cc. of

Bacterium tumefaciens in the leaf axil was 2.7 cm. which is slightly larger than the average for galls produced by inoculating the axil of a leaf of a decapitated plant with 6a and smaller than the average for galls resulting from a drop of 6e (forty times weaker) inoculated in the leaf axil, a region which gives the maximum reaction to the crown gall organism.

SUMMARY AND CONCLUSION

1. Tobacco plants of uniform age and size and growing under uniform conditions of soil and light were inoculated with *Bacterium tumefaciens* to determine the effect of various dilutions of a given culture on the size of the crown gall produced. In these experiments I have not counted the organisms in the inoculating medium, but have used measured quantities of inoculum varying from ordinary agar culture emulsion to dilutions 1 : 100.
2. No constant difference was noted in the size of the crown gall resulting from an inoculation with the undiluted bacterial emulsion and a suspension forty times weaker.
3. The difference in the quantity of the suspension inoculated showed that the quantity of *Bacterium tumefaciens* was not effective in increasing the size of the gall. The differences observed when trocar and needle are compared must be referred to the relative degree of injury and number of cells exposed.
4. Suspension from cultures of *Bacterium tumefaciens* two days old were found to be no more effective in producing crown gall in tobacco than were cultures twenty-one and forty days old.
5. It is concluded that the number of cells of *Bacterium tumefaciens* inoculated into the tobacco is not significant in determining the size of the crown gall. A smaller number of bacteria favorably lodged in tissue capable of response will produce a crown gall equal in size to that produced by a larger number.
6. The size of the crown gall is rather dependent upon the region of the host inoculated and the vitality of the host, than upon the number of bacteria starting the infection.

LITERATURE CITED

Tappeiner, —, 1878. Ueber eine neue Methode Tuberculose zu erzeugen. Virchow's Archiv **74:** 393-400.

———, 1880. Neue experimentelle Beiträge zur Inhalations-tuberculose der Hunde. Virchow's Archiv **82:** 353–359.

Gebhardt, F., 1890. Experimentelle Untersuchungen über den Einfluss der Verdünnung auf die Wirksamkeit des tuberculösen Giftes. Virchow's Archiv **119:** 127–148. *pl. 4.*

Preyss, A., 1891. Ueber den Einfluss der Verdünnung und der künstlich erzeugten Disposition auf die Wirkung des inhalirten tuberculösen Giftes. Münchener Med. Wochenschr. **38:** 418–420, 440–443.

Bolley, H. L., 1902. The use of the centrifuge in diagnosing plant disease. Proc. Soc. Prom. Agr. Sc. **23:** 82–85.

Cobb, N. A., 1904. Quantitative estimation of disease spores. Agr. Gaz. New South Wales **15:** 670–680.

———, 1905. Quantitative estimation of bunt in seed-wheat. Agr. Gaz. New South Wales **16:** 1113–1117.

Hutyra, F., 1905. Schutzimpfungsversuche gegen die Tuberculose der Rinder nach v. Behring's Methode. Beiträge Exp. Therapie **9:** 1–17.

Findel, H., 1907. Vergleichende Untersuchungen über Inhalations- und Fütterungstuberkulose. Zeitschr. Hyg. Infekt. Krankh. **57:** 104–153.

Barber, M. A., 1907. On heredity in certain micro-organisms. Kansas Univ. Sc. Bull. **4:** 3–48. *pl. 1–4.*

Adami, J. G., 1908. The Principles of Pathology **1.**

Smith, T., 1908. The vaccination of cattle against tuberculosis. Jour. Med. Res. **13:** 451–485.

Webb, G. B., Williams, W. W., & Barber, M. A., 1909. Immunity production by inoculation of increasing numbers of bacteria beginning with one living organism. Jour. Med. Res. **20:** 1–25.

Levine, M., 1919. Studies on plant cancers—I. The mechanism of the formation of the leafy crown gall. Bull. Torrey Club **46:** 447–452. *pl. 17, 18.*

———, 1921(a). Studies on plant cancers—II. The behavior of crown gall on the rubber plant (*Ficus elastica*). Mycologia **13:** 1–11. *pl. 1, 2.*

———, 1921 (b). Studies on plant cancers—III. The nature of the soil as a determining factor in the health of the beet, *Beta vulgaris*, and its relation to the size and weight of the crown gall produced by inoculation with *Bacterium tumefaciens*. Am. Jour. Bot. **8**: 507–525. *f. 1–9.*

———, 1923. Studies on plant cancers—V. Leafy crown galls on tobacco plants resulting from *Bacterium tumefaciens* inoculations. Phytopathology **13**: 107–116. *pl. 5–7.*

Heald, F. D., 1921. The relation of spore load to the per cent of stinking smut appearing in the crop. Phytopathology **11**: 269–278.

Diagnoses of American Porias—II*

L. O. Overholts

(WITH PLATES 13 AND 14 AND THREE TEXT FIGURES)

Poria corticola (Fr.) Cooke, Grevillea **14**: 113. 1886
Polyporus corticola Fr. Syst. Myc. **1**: 385. 1821.

Original Description: Effusus, firmus, glaber, albus, punctis confertis nudis. Duplex status lectus: a) *populneus*, seriato-elongatus, confluens, crassior, adhaerens, tuberculosus, pallescens, margine spurio tumido villoso, punctis rotundis aequalibus. b) *fagineus*, latissime effusus punctis integris. Ad cortices putridos. Populi. b. Fagi. Per annum (V.V.).

Redescription: Annual, soft and watery when fresh, broadly effused for many centimeters where best developed, separable when mature but young specimens closely adnate, typically with a thin pubescent, narrowly sterile margin, but this sometimes completely fertile and sometimes broadly sterile and membranous; subiculum very thin, inconspicuous, white, not more than 0.5 mm. thick; tubes unstratified, 2–5 mm. long, the mouths white when fresh, white or more commonly yellowish (cinnamon buff) on drying, often glistening, angular, very thin-walled, entire or becoming finely dentate-lacerate, averaging 2–4 per mm.; spores ellipsoid or oblong-ellipsoid, smooth, hyaline, commonly showing a tendency to cohere in groups of two to four, $4.5–5.5 \times 3–3.5\ \mu$; cystidia various, but usually present, either as fusoid projecting bodies, as smaller fusoid capitate-incrusted organs, or as entirely incrusted projecting organs, all 3–7 μ diameter; hyphae rather flexuous, simple or sparingly branched, with occasional cross walls but no clamps, diameter 2–4 μ in trama, 3–6 μ in subiculum.

On bark and wood of deciduous trees; recorded from *Acer*, *Fagus*, and *Populus*.

Specimens Examined: Swan River, Manitoba, Canada; Winnipeg, Manitoba, Canada (three collections); Harrisville, New York; Stone Valley, Pennsylvania; Chain Bridge, Maryland; West Elkton, Oberlin, and Oxford, Ohio; Creve Coeur Lake, Missouri (two collections); Custer, South Dakota; Missoula, Montana; Priest River, Idaho.

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* Contribution from the Department of Botany, The Pennsylvania State College, No. 42. For the first paper of this series, see Mycologia **14**: 1–11. *pl. 1 + f. 1–6.* 1922.

P. corticola is a soft white species (PLATE 13, FIGS. 1, 2) that appears to be fairly common from New York to the Rocky Mountains. Egeland (Norsk. res. Poresv. p. 143) reports it as occurring chiefly on aspen and birch in Norway. My records show *Acer* (including *A. Negundo*) to be its common host though found on both *Populus tremuloides* and *P. trichocarpa*. In the Ohio Valley it seems to frequent the beech. Sometimes it is strictly a bark-inhabiting fungus but just as frequently it grows on decorticated wood, particularly wood in advanced stages of decay—a fact that is responsible for the lack of information in many collections as to the exact substratum.

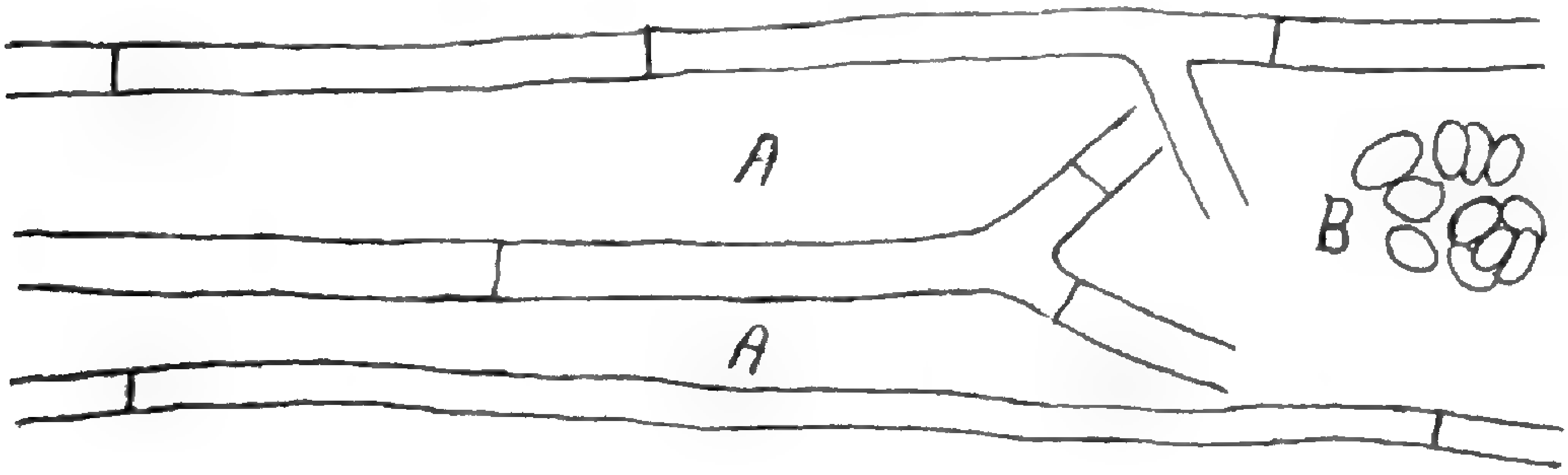

FIG. 1. PORIA CORTICOLA (Fr.) Cooke. A, Hyphae showing cross walls and absence of clamp connections; B, Spores, some characteristically agglutinated in groups.

As here interpreted the species is, in its microscopic characters, quite a variable one. Our American plant differs so markedly in the matter of cystidia that it might well be held to be at least a separate variety. In the European specimens I have examined and as reported by Egeland (Norsk. res. Poresv. p. 143), conspicuous cystidia are present in the hymenium. PLATE 13, FIGS. 3, 4, show these bodies as seen in plants from Sweden. Egeland also reports, and I have verified his statement in my study of Swedish specimens, that other bodies, which he terms paraphyses, with capitate-incrusted apices, are present with the cystidia, and in fact in some specimens I find this to be about the only cystidium-like organ present. In American collections the type of cystidium that approaches nearest to the well-developed form in European specimens is shown in PLATE 13, FIG. 5, made from a Pennsylvania collection taken in 1920, though they have been seen occasionally in another collection from Ohio. More frequently the capitate-incrusted type is present, as seen in PLATE 13, FIG. 6; and this type grades over into a more heavily incrusted form, as represented in PLATE 13, FIG. 7, where they have the form and appearance of those found in *Fomes connatus*. Indeed, in the absence of spores, I had previously referred specimens of this type to a resupinate condition of that species.

The close microscopic agreement of all the plants with these variable structures and with other characters mentioned below, and the gradations and apparent relationships of these structures themselves seem to imply a relationship that can be readily embraced within the limits of a single species. About the only other American plant that shows cystidia comparable to those of the European *P. corticola* is *P. aurea* Peck, which seems to differ sufficiently in the shape and size of the spores, the presence of clamp connections, and other features, to warrant keeping it distinct.

Nearly all of the specimens I have referred to this species have another peculiar microscopic character in the tendency of the spores to cohere in groups of two to four (TEXT FIG. 1). The hyphae are also more or less distinctive in the presence of occasional distinct cross walls without clamp connections.

The variability of the species will make it difficult to recognize at times. The essential characters seem to be the soft white plant widely effused on hardwoods, the tubes well developed, the hyphae with rather frequent cross walls (TEXT FIG. 1), and in addition one or more of the following characters: (a) well-developed hyaline projecting unincrusted cystidia; (b) capitate-incrusted paraphyses (?); (c) heavily incrusted irregular projecting cystidia; and (d) ellipsoid spores cohering in small groups.

PORIA INERMIS Ellis & Everhart, Proc. Acad. Nat. Sci. Philadelphia **1894**: 322. 1894

Original Description: Resupinate, adnate, seriate, extending along the limb for 6 in. or more and about 1 in. wide, yellowish-brown, 2–4 mm. thick in the middle, margin thin, narrow, light yellow (when fresh), and closely adnate; pores small, round, extending down to the underlying wood. Spores ferruginous, subglobose, 4–5 μ in diameter. (No spines).

On dead shrubs and limbs of various deciduous trees, Newfield, N. J. Received also from Michigan, Canada, Nebraska, and Louisiana. Issued in N. Am. Fung. No. 313 as *P. obliquus* from which it is quite distinct.

Redescription: Perennial or at least persisting for three or four years, effused for 6–30 cm. in narrow elongated patches on small shrubs or branches and 1–3.5 cm. broad, inseparable, firm and corky in texture, with a narrow bright colored, yellow brown (honey yellow to clay color) sterile border rarely more than 1 mm. broad; subiculum extremely thin, inconspicuous, brown; tubes usually oblique, 1–3 mm. long, not stratified though increasing in length for several successive seasons, the mouths dark honey yellow to snuff brown or cinnamon brown, finally weathering to grayish brown, at first sub-rounded and minutely pubescent, then somewhat angular and more glabrous, averaging 3–4 per mm., the dissepiments rather thin but entire; hymenium much cracked in mature specimens; spores broadly ellipsoid and flattened on one side, or nearly globose, brown, smooth, 5–6 × 3–4 μ; cystidia and setae none; hyphae light to dark brown, mostly unbranched and with cross walls only in the lighter colored hyphae, no clamps, diameter 2.5–3 μ.

On dead limbs and trunks of a limited number of small shrubs; including *Alnus*, *Ilex*, and *Nemopanthus*.

Specimens Examined: Amherst, Massachusetts; Tripoli, West Fort Ann, and Bronx Park, New York; Scotia and Bear Meadows (three collections), Pennsylvania; Ann Arbor, Michigan.

Ellis and Everhart report the species, as will be noted, as occurring on limbs and shrubs of various deciduous trees, though no statement is made as to just what hosts are involved. The species is well represented at New York but I have not studied the collections, though Mr. Percy Wilson who has collected it many times tells me that he always finds it on *Ilex*. This and *Nemopanthus*, a closely related genus, represent the usual hosts on which I have been able to discover it, though Dr. P. J. Anderson sends me a Massachusetts specimen on *Alnus*, and I have myself made one collection on that host.

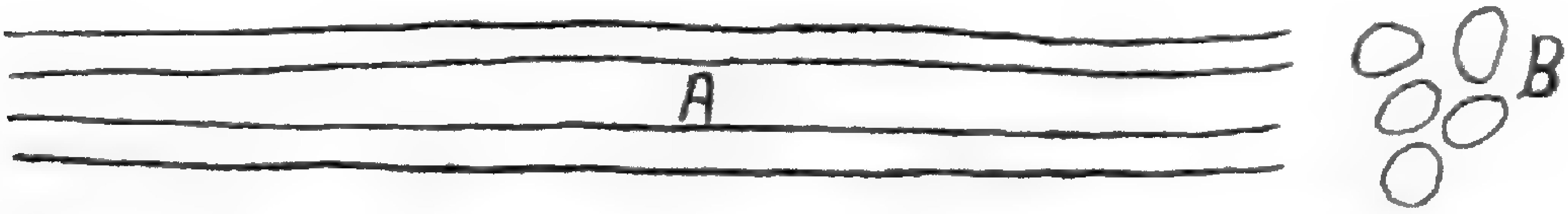

FIG. 2. PORIA INERMIS Ellis & Everhart. A, Hyphae from the trama; B, Spores.

The form assumed by the plant is characteristic (PLATE 14, FIGS. 5, 6), though necessitated by the smallness of the limbs or trunks on which it grows. I have seen no specimens on trunks larger than 3.5 cm. in diameter and the average size is 2–2.5 cm. Since it nearly always grows on standing trunks the tubes are usually very oblique. In age the hymenium becomes cracked (PLATE 14, FIGS. 5, 6), due probably to the shrinkage caused by the drying out of the dead stem and by the decay brought on by the fungus. The margin of the plant is frequently quite irregular in outline or in older plants is apt to become somewhat thickened by reason of the receding growth of the fungus. The first year's growth is often not more than a millimeter thick. In old dead and dying specimens the margins of the fungus loosen somewhat from the substratum.

The species is one of the easiest of the Porias to identify. It is about the only brown species with brown spores, and brown spores in all specimens are nearly always to be found in abundance in the hymenium. The lack of setae is also noteworthy in brown Porias (PLATE 14, FIG. 7).

The original description reports the species from Canada, Michigan, Nebraska, and Louisiana. In this entire range various species of *Ilex* are present.

PORIA MEDULLA-PANIS (Pers.) Cooke, Grevillea **14**: 109. 1886

Boletus medulla-panis Pers. Syn. Method. Fung. 544. 1801.

Original Description: (Albus durus) effusus planus crustaceus, superne perforatus; tubulis obliquis (rectisque).

B. longissima, subterranea. Praesertim frequens ad ligna fabrefacta ex. gr. ianus vetustas, hortorum, aut in sylvis ad truncos aridos, inuenitus, oblique glaber, siccus. Pori pro loco et situ nuc recti, nunc oblique sunt.

Redescription: Annual or reviving for several years and eventually as much as 1 cm. thick, broadly effused for many centimeters, inseparable or separating only with difficulty, typically with a rather conspicuous pubescent or compactly tomentose margin, white to cream buff in color: subiculum a thin pallid layer that in old specimens practically disappears as such; tubes finally indistinctly stratified in three or four layers or sometimes distinctly so with thin layers of context separating the year's growth, 0.5–3 mm. long each season, the mouths pure white to antimony yellow or egg yellow, at first circular and thick-walled, often angular and thin-walled at maturity, always entire, often oblique, averaging 3–5 per mm.; spores ellipsoid to oblong-ellipsoid or broadly ellipsoid, smooth, thin-walled, hyaline, 4–6 × 3–4 μ; basidia broadly clavate to pyriform, 5–8 μ in diameter; cystidia none or represented by pointed fusoid hyaline paraphysis-like bodies; abundant large crystals present in the tramal tissue and along the hymenium; hyphae very variable, in thin and compact collections from dry substrata rigid, much branched, 1.5–3 μ diameter; in better developed collections less branched or unbranched, 2–5 μ diameter; all without apparent cross walls and clamps.

On bark and wood of deciduous trees; recorded from *Acer, Artemisia, Castanea, Fagus, Fraxinus, Gleditsia, Liriodendron, Ostrya, Populus, Prunus, Quercus, Rhus, Robinia, Tilia,* and *Ulmus.* Often on fence posts and other structural timbers.

Specimens Examined: Ormstown, Quebec, Canada; North Conway, New Hampshire; Greenwood, Massachusetts; Knowersville, North Greenbush, and Sylvan Beach, New York; Westport, State College, and Greenwood Furnace, Pennsylvania; Richwood and Monmouth Junction, New Jersey; Chain Bridge, Maryland; Morgantown, Thomas, and Seneca, West Virginia; Arlington, Virginia; Fort Valley, Georgia; West Elkton (three collections), Oxford (eleven collections), and Cincinnati, Ohio; West Lafayette, Indiana; Geneseo and Cerro Gordo, Illinois; New Richmond, Frankfort, and Ann Arbor, Michigan; St. Louis County, Wicks, Meramec Highlands, and St. Louis, Missouri; Camp Pike, Arkansas; St. Paul, Minnesota; Blue Mounds, Wisconsin; Darby, Montana; Tolland, Colorado (three collections); Guadaloupe, California.

There are in my herbarium nearly sixty collections of this species with a range from New Hampshire to Georgia and west to California. As would be expected the species shows quite a bit of variation in this range. Bresadola and Murrill have already indicated *P. pulchella* Schw. as a synonym and after a close study of all these collections I find myself in agreement with them. I would also add *P. Xantholoma* Schw. to the list of synonyms. The species varies from a thin compact, rather hard plant (PLATE 14, FIG. 2), that often cracks on drying, to a more coriaceous or leathery plant (PLATE 14, FIG. 1) somewhat separable from the substratum. The first form is typical of the plant as it grows in dry exposed situations such as on fence posts, fence rails and structural timbers. This form usually has narrow rigid hyphae (TEXT FIG. 3) that are much branched and less than 3 µ in diameter. The second form is more characteristic of the plant as it grows in more protected situations, and here the narrow rigid hyphae give place, entirely or in part, to wider and nearly simple hyphae 3–5 µ in diameter (TEXT FIG. 3). But all sorts of intergrading conditions exist so that neither on these characters nor on any others can the two forms be kept distinct. Then in coloration there is a nearly white form characteristic of plants where protected from the light, a gray or pallid form where exposed to considerable illumination, and finally a bright colored form with almost egg yellow hymenium whose relation to light I have not determined. This last form is more rarely met. I have specimens of it from New Jersey, Georgia, and Illinois. Through all these variations the hymenial characters are very constant (PLATE 14, FIGS. 3, 4). Spores are usually found in abundance (TEXT FIG. 3), even in crushed preparations of the hymenium, and often have a collapsed and empty appearance.

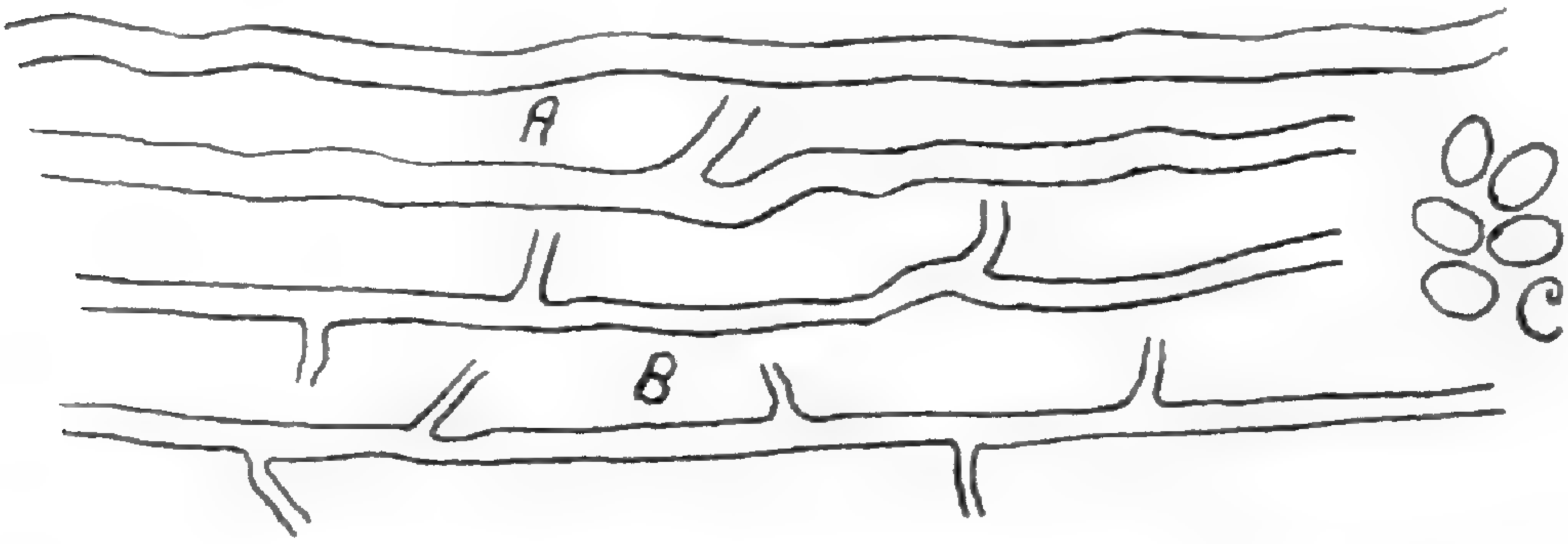

FIG. 3. PORIA MEDULLA-PANIS (Pers.) Cooke. A, B, Hyphae showing variations in amount of branching and considerable variation in diameter, the narrow, much branched ones being characteristic of the xerophytic form of the species; C, Spores.

The species is closely related to *P. subacida* Peck, which shows the same microscopic characters as the form of *P. medulla-panis* with the larger hyphae. Other microscopic characters possessed by both are the large basidia, the ellipsoid spores, and the abundance of crystals in the tramal tissue. Yet I have admitted here no specimens from a coniferous substratum, though perhaps the thick form referred to in a previous paper by me (Bull. N. Y. State Mus. 205–06: 114. 1919) should really be included here.

I am at present inclined to that opinion, but to admit these plants would extend the host range of this species to include wood of at least the main coniferous trees and give a gradation into typical *P. subacida* that would be extremely confusing. Yet in view of the close similarity in microscopic characters it might simplify matters to refer all these plants to such a one protean species.

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Explanation of plates 13 and 13

The photomicrographs in this paper are from free hand sections cut by the writer from herbarium specimens and mounted in glycerine. I have had the assistance of Mr. P. F. Shope in the preparation of the illustrations.

PLATE 13

PORIA CORTICOLA (Fr.) Cooke

FIG. 1. Photograph, × 1½. Overholts Herbarium, No. 5027.

FIG. 2. Same, showing older specimens but with a membranous margin and the tubes more or less collapsed. Overholts Herbarium, No. 4211.

FIG. 3. Photomicrograph of cross section of hymenium of Swedish specimens, showing the angular pores and the distribution of the cystidia, × 160.

FIG. 4. Photomicrograph of same specimen showing a cluster of cystidia, × 320.

FIG. 5. Closest approach in American specimens to the cystidial condition of European *P. corticola.* Cystidia represented at a, b, c, and d. Overholts Herbarium. No. 5912.

FIG. 6. Photomicrograph, × 320, showing the small capitate incrusted cystidia that project only slightly beyond the basidia. Overholts Herbarium. No. 8019.

FIG. 7. Photomicrograph, × 320, showing a somewhat more heavily incrusted cystidium sometimes present. Overholts Herbarium, No. 4211.

PLATE 14

FIGS. 1–4. PORIA MEDULLA-PANIS (Pers.) Cooke

FIG. 1. Photograph, × 1½, of a specimen of the more flabby and coriaceous type of this species. Overholts Herbarium, No. 5682.

FIG. 2. Photograph, × 1½. showing the harder, more adnate and general xerophytic type of the species. Overholts Herbarium, No. 4108.

FIG. 3. Photomicrograph, × 160, of cross section of the hymenium. Overholts Herbarium, No. 34.

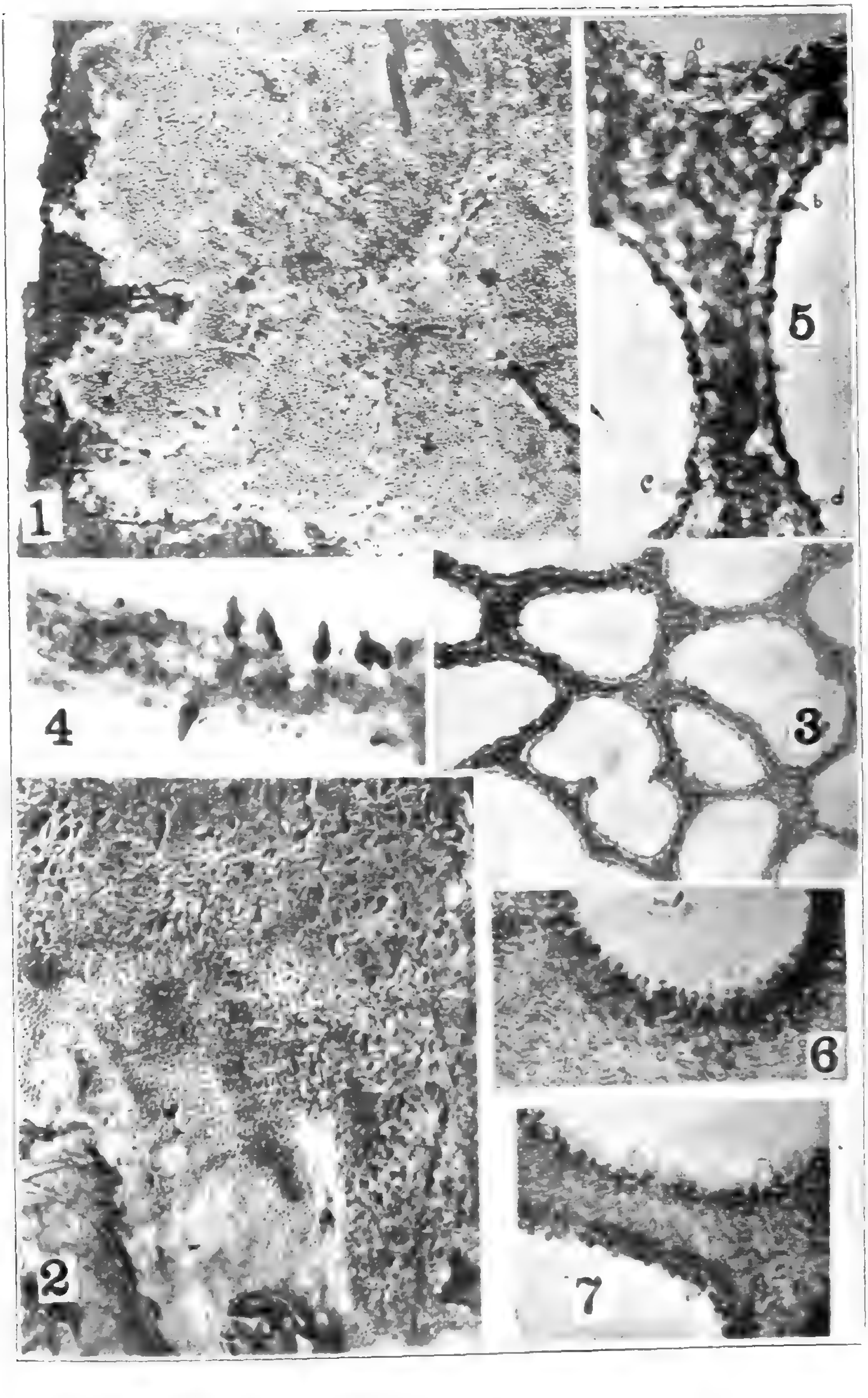
FIG. 4. Photomicrograph, × 320, showing small portion of the hymenial region of the same plant.

FIGS. 5–7. PORIA INERMIS Ellis & Everhart

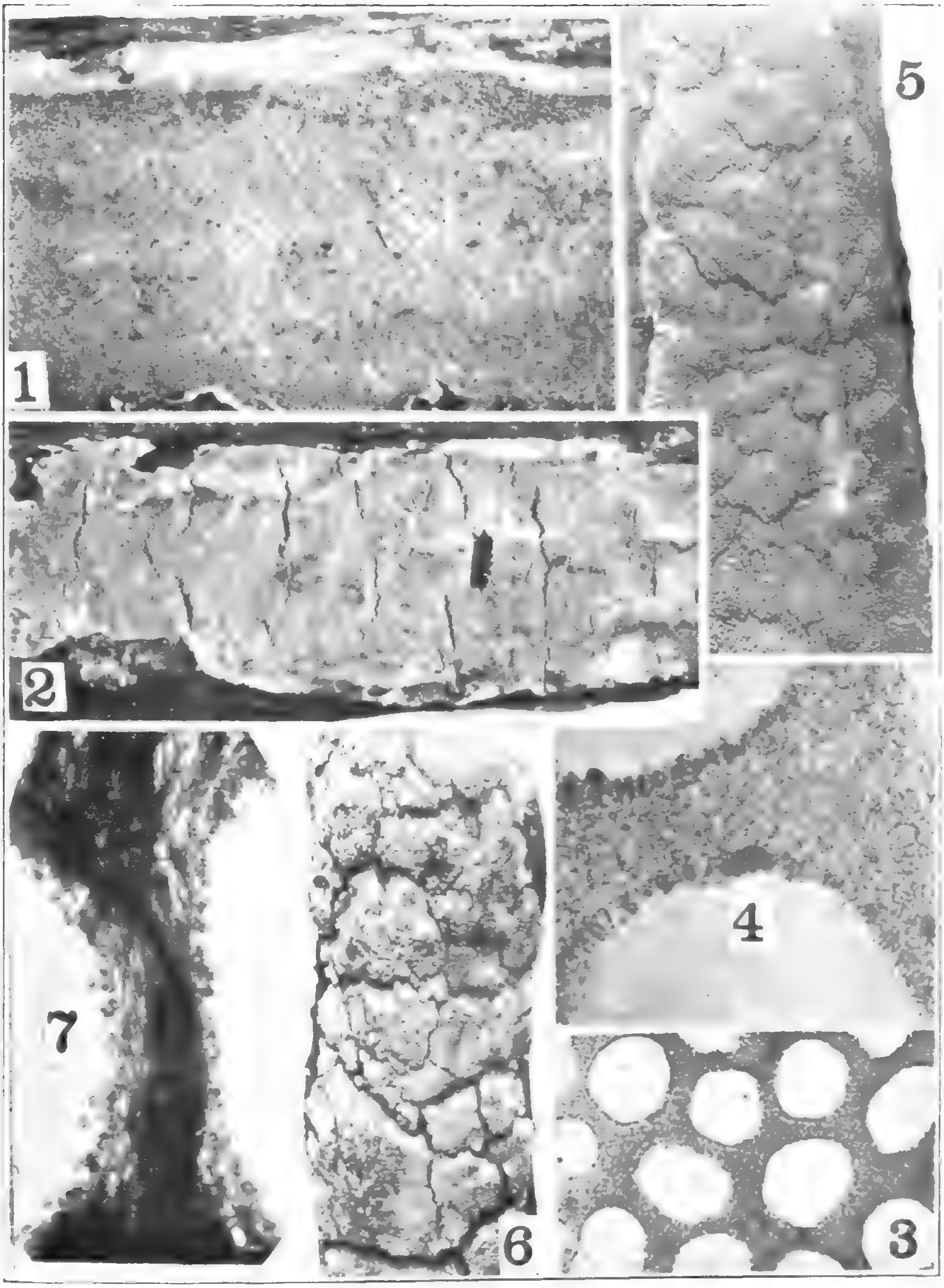
FIG. 5. Photograph, × 1½, of the usual type of the species, with a narrow sterile margin and the hymenium showing somewhat of a tendency to crack. Overholts Herbarium No. 5432.

FIG. 6. Photograph, × 1½, of an older specimen, somewhat discolored and with the hymenium much cracked. Overholts Herbarium No. 4794.

FIG. 7. Photomicrograph, × 320, showing portion of the hymenium, with absence of setae and with the brown globose spores. Overholts Herbarium, No. 4794.



PORIA CORTICOLA (Fr.) Cooke



1–4. PORIA MEDULLA-PANIS (PERS.) COOKE
5–7. PORIA INERMIS ELLIS & EVERHART

INDEX TO AMERICAN BOTANICAL LITERATURE
1920-1922

The aim of this Index is to include all current botanical literature written by Americans, published in America, or based upon American material; the word America being used in the broadest sense.

Reviews, and papers that relate exclusively to foresty, agriculture, horticulture, manufactured products of vegetable origin, or laboratory methods are not included, and no attempt is made to index the literature of bacteriology. An occasional exception is made in favor of some paper appearing in an American periodical which is devoted wholly to botany. Reprints are not mentioned unless they differ from the original in some important particular. If users of the Index will call the attention of the editor to errors or omissions, their kindness will be appreciated.

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Sherman, E. A. The forests and our future. For. Leaves **18**: 187–192. D 1922.

Shimek, B. *Quercus lyrata* in Iowa. Bull. Torrey Club **49**: 293–295. *pl. 16, 17.* 11 O 1922.

Shufeldt, R. W. The kudzu vine and other climbers. Am. For. **28**: 532–540. *f. 1–13.* S 1922.

Siggers, P. V. *Torula ligniperda* (Willk.) Sacc.—a hyphomycete occurring in wood tissue. Phytopathology **12**: 369–374. *pl. 24.* 11 S 1922.

Sinnott, E. W. Inheritance of fruit shape in *Cucurbita Pepo*—I. Bot. Gaz. **74**: 95–103. *f. 1–3.* 15 S 1922.

Sinotô, Y. On the nuclear divisions and partial sterility of *Oenothera Lamarckiana* Ser. Bot. Mag. [Japan] **36**: 92–98. *f. 1–4.* Au 1922.

Skottsberg, C. The phanerogams of Easter Island. Nat. Hist. Juan Fernandez & Easter Is. **2**: 61–84. *pl. 6–9 + f. 1, 2.* 1922.

Includes 4 new species.

Skottsberg, C. The phanerogams of the Juan Fernandez Islands. Nat. Hist. Juan Fernandez & Easter Is. **2**: 95–240. *pl. 10–20 + f. 1–39.* 1922.

Includes *Margyracaena*, gen. nov., and 22 new species.

Small, J. Age and area, and size and space, in the Compositae. In Willis, J. C., Age and area 119–136. 1922.

Small, J. K. *Aconogonum polystacyum.* Addisonia **7**: 21, 22. *pl. 235.* 25 S 1922.

Small, J. K. The blue-stem—*Sabal minor.* Jour. New York Bot. Gard. **23**: 161–168. N. 1922.

Small, J. K. The botanical fountain of youth. Jour. New York Bot. Gard. **23**: 117–133, 139–155. *pl. 275, 276, 278, 279.* 1922.

Small, J. K. The saw-cabbage palm. The history and distribution of *Paurotis Wrightii.* Jour. New York Bot. Gard. **23**: 61–70. *pl. 271–273.* Je 1922.

Smith, C. O. Pathenogenicity of the olive knot organism on hosts related to the olive. Phytopathology **12**: 271–278. *pl. 21, 22.* 12 Au 1922.

Smith, C. P. Studies in the genus *Lupinus*—VII. Bull. Torrey Club **49**: 197–206. *f. 75–78.* 10 Au 1922.

Smith, E. F. Fasciation and prolepsis due to crown gall. Phytopathology **12**: 265–270. *pl. 16–20.* 12 Au 1922.

Smith, E. P. Comparative studies on respiration—XXII. The effect of lactic acid on the respiration of wheat. Am. Jour. Bot. **9**: 307–310. *f. 1, 2.* 12 Jl 1922.

Snapp, O. I., Turner, W. F., & Roberts, J. W. Controlling the curculio, brown rot, and scab in the peach belt of Georgia. U. S. Dept. Agr. Circ. 216: 3–30. *f. 1–17.* My 1922.

Snell, ,W. H., & Howard, N. O. Notes on chemical injuries to the eastern white pine (*Pinus Strobus* L.). Phytopathology **12**: 362–368. *pl. 24 + f. 1, 2.* 11 S 1922.

Souèges, R. Recherches sur l'embryogénie des Solanacées. Bull. Soc. Bot. France **69**: 163–178, 236–241. *f. 1-52.* 1922.

Spegazzini, C. Crytogamae nonnullae fuegianae. An. Soc. Ci. Argentina **44:** 59–85. *f. 1–6.* Au 1922.

Spegazzini, C. Micromycetes nonnulli brasilienses. An. Soc. Ci. Argentina **93:** 111–118. *f. 1–35.* Ap 1922.

Includes new species in *Sphaerophragmium*, *Meliola*, *Sphaerella*, *Parapelella*.

Spessard, E. A. Prothallia of *Lycopodium* in America—II. Bot. Gaz. **74:** 392–413. *pl. 16–18.* 21 D 1922.

Sponsler, O. L. The structure of the starch grain. Am. Jour. Bot. **9:** 471–492. *f. 1–9.* 27 N 1922.

Sprague, T. A. The type-species of *Bignonia*. Jour. Bot. **60:** 363, 364. D 1922.

Standley, P. C. Botanical exploration in Central America. Jour. New York Bot. Gard. **23:** 168–175. N 1922.

Standley, P. C. *Diospyros Conzattii*, a new species of persimmon from Mexico. Jour. Washington Acad. Sci. **12:** 399, 400. 19 O 1922.

Standley, P. C. Trees and shrubs of Mexico (Fagaceae—Fabaceae). Contrib. U. S. Nat. Herb. **23:** 171–515. 1922.

Stevens, N. E. Environmental temperatures of fungi in nature. Am. Jour. Bot. **9:** 385–390. *f. 1.* 30 Au 1922.

Stone, R. E. Leaf scorch or mollisiose of the strawberry. Phytopathology **12:** 375–380. *f. 1–3.* 11 S 1922.

Stout, A. B. *Lilium canadense.* Addisonia **7:** 61, 62. *pl. 255.* 30 D 1922.

Stout, A. B. *Lilium Parryi.* Addisonia **7:** 49, 50. *pl. 249.* 30 D 1922.

Stout, A. B. *Lilium superbum.* Addisonia **7:** 59, 60. *pl. 254.* 30 D 1922.

Stout, A. B. *Lilium tigrinum.* Addisonia **7:** 53, 54. *pl. 251.* 30 D 1922.

Stout, A. B. Preliminary report of investigations with species of *Lilium*. Jour. New York Bot. Gard. **23:** 155–158. O 1922.

Ström, K. M. Freshwater algae from Juan Fernandez and Easter Island. Nat. Hist. Juan Fernandez & Easter Is. **2:** 85–93. *f. 1.* 1922.

Surgis, E. Recherches sur les Frankéniacées (cont.). Rev. Gen. Botanique **34:** 450–462. *f. 1–6.* Au 1922.

Sydow, H., & Petrak, F. Ein Beitrag zur Kenntnis der Pilzflora Nordamerikas, insbesondere der nordwestlichen Staaten. Ann. Myc. **20:** 178–218. 1922.

Contains many new species.

Tanaka, T. New Japanese fungi. Notes and translations.—XII. Mycologia **14:** 282–295. 1 S 1922.

Tanner, F. W. Microbiology of flax retting. Bot. Gaz. **74:** 174–185. 16 O 1922.

Taylor, M. W. Potential sporidia production per unit in *Cronartium ribicola.* Phytopathology **12:** 298–300. *f. 1.* 12 Au 1922.

Taylor, W. P. A distributional and ecological study of Mount Rainier, Washington. Ecology **3:** 214–236. *f. 1–4.* Jl 1922.

Taylor, W. R. Notes on some algae from British Columbia. Rhodora **24:** 101–111. *f. 1.* 28 Au 1922.

Includes *Rhizoclonium Selkirkii,* sp. nov.

Taylor, W. R. Organization of heterotypic chromosomes. Science II. **56:** 635. 1 D 1922.

Taylor, W. R. Recent studies of Phaeophyceae and their bearing on classification. Bot. Gaz. **74:** 431–441. 21 D 1922.

Tharp, B. C. *Commelinantia,* a new genus of the Commelinaceae. Bull. Torrey Club **49:** 269–275. *pl. 10, 11.* 22 S 1922.

Thaxter, R. A revision of the Endogoneae. Proc. Am. Acad. Arts & Sci. **57:** 291–350. *pl. 1–4.* Je 1922.

Includes 9 new species.

Thériot. I. *Leptobryum Escomeli* Thér., sp. nov. Bryologist **25:** 90–92. 7 N 1922. [Illust.]

From Peru.

Thommen. G. Notes on the fern leaf industry. Am. Fern Jour. **12:** 122–125. 30 D 1922.

Thompson, H. C., & Beattie, J. H. Group classification and varietal descriptions of American varieties of sweet potatoes. U. S. Dept. Agr. Bull. 1021: 1–30. *pl. 1–8.* 17 Ap 1922.

Thompson, J. M. Studies on floral morphology—II. The staminal zygomorphy of *Couroupita guianensis* Aubl. Trans. Roy. Soc. Edinburgh **53:** 1–15. *pl. 1–5 + f. 1–3.* 1922.

Thone, F. Ecological factors in region of Starved Rock, Illinois. Bot. Gaz. **74:** 345–368. *f. 1–5.* 21 D 1922.

Tiffany, L. H. Some algal statistics gleaned from the gizzard shad. Science II. **56:** 285, 286. 8 S 1922.

Tisdale, W. H. Seedling blight and stack-burn of rice and the hot-water seed treatment. U. S. Dept. Agr. Bull. 1116: 1–11. *pl. 1–6 + f. 1,2.* 13 N 1922.

Torrend, C. Les Polyporacées du Brésil (cont.). Broteria Bot. **20:** 107–112. 1922.

Tucker, E. M. Bibliographical notes. Jour. Arnold Arb. **3:** 227–231. D 1922.

Turner, T. W. Studies of the mechanism of the physical effects of certain mineral salts in altering the ratio of top growth to root growth in seed plants. Am. Jour. Bot. **9:** 415–445. 20 O 1922.

Uphof, J. C. T. Der Anbau und Verkauf von Citrusobst in den Vereinigten Staaten. Tropenpflanzer **25:** 72–83. Je 1922.

Uphof, J. C. T. Der Loquat (*Eriobotrya japonica*) in den Vereinigten Staaten. Tropenpflanzer **25:** 41–43. Ap 1922.

Uphof, J. C. T. Vegetationsbilder aus Kalifornien. Vegetattionsbilder XIV. **7:** *pl. 37–42,* with text. 1922.

Urban, I. Plantae haitienses novae vel rariores a cl. Er. L. Ekman 1917 lectae. Arkiv Bot. **17**^{7}: 1–72. 15 My 1922.

Includes 2 new genera and 59 new species.

Vaupel, F. *Echinopsis formosa* (Pfeiff.) Jac. Monats. Kakteenk. **32:** 148. N 1922. [Illust.]

Vries, H. de Age and area and the mutation theory. In Willis, J. C., Age and area 222–227. 1922.

Waksman, S. A. The influence of soil reaction upon the growth of Actinomycetes causing potato scab. Soil Sci. **14:** 61–76. Jl 1922.

Walker, L. B. The forceful ejection of the glebal mass by *Sphaerobolus*. Proc. Nebraska Acad. Sci. **5:** 23–25. S 1922.

Walton, G. P. Specific acidity of water extract and oxalate content of African sorrel. Bot. Gaz. **74:** 158–173. *f. 1.* 16 O 1922.

Rumex abyssinicus Jacq.

Waterman, W. G. Development of plant communities of a sand ridge region in Michigan. Bot. Gaz. **74:** 1–31. *f. 1–12.* 15 S 1922.

Weaver, J. E., & Crist, J. W. Relation of hardpan to root penetration in the Great Plains. Ecology **3:** 237–249. *f. 1–4.* Jl 1922.

Weber, G. F. *Septoria* diseases of cereals. Phytopathology **12:** 449–470. *pl. 29, 30 + f. 1–5.* 5 D 1922.

Includes *Leptosphaeria avenacea*, sp. nov.

Weberbauer A. Las zonas de lluvia y de vegetacion en el departamento de Piura y la provincia de Jaen [Peru]. Arch. Asoc. Peruana Prog. Cien. **1:** 107–117. 1921.

Weingart, W. *Cereus Rothii* Weingart, spec. nov. Monats. Kakteenk. **32:** 146–148. N 1922.

From Paraguay.

Weingart, W. *Cereus Spegazzinii* Web. und Verwandte. Monats. Kakteenk. **32:** 161–163. D 1922.

Welles, C. G. *Cercospora* leaf-spot of *Averrhoa Carambola*. Philipp. Jour. Sci. **19:** 747–752. *pl. 1, 2.* D 1921.

Welles, C. G. *Cercospora* leaf-spot of coffee. Philipp. Jour. Sci. **19:** 741–746. *pl. 1.* D 1921.

Vol. 50 No. 8

BULLETIN

OF THE

TORREY BOTANICAL CLUB

AUGUST, 1923

Notes on Fabaceae—II

Per Axel Rydberg

HOMALOBUS Nutt. (*con.*)

D. Campestres

This group differs from the *Tenelli* not only in the narrow strictly sessile pod but in the acute keel-petals, a character which as far as I know separates it from all the other groups of *Homalobus*.

21. Homalobus campestris Nutt. This was described from specimens collected on the "Colorado of the West," meaning some of the tributaries of the Green River. One specimen of Nuttall's is in the Torrey Herbarium and is in flower. The calyx is 5 mm. long, more or less black-hairy; the lobes are subulate, decidedly longer than broad; nearly every leaf has one or two pairs of lateral leaflets, and the terminal leaflet is represented by the flattened, somewhat falcate prolongation of the rachis. The corolla is evidently ochroleucous, without a trace of purple. Gray, in transferring this species to *Astragalus*, evidently confused it with some other member of the group, describing the leaves as having often nine to thirteen leaflets and the corolla as being yellowish white, usually tinged with purple. He also regarded *H. tenuifolius* Nutt. as a depauperate form and evidently had in mind *H. hylophilus* Rydb., *H. oblongifolius* Rydb. and their allies. As *Astragalus campestris* was preoccupied, Greene substituted the name *A. convallarius*. Jones at first made the plant *A. serotinus campestris*,* but cited under this name specimens belonging to other species, one of them, *6015n*,

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* Proc. Calif. Acad. II. **5**: 668. 1895.

[The Bulletin for July (**50**: 231–260. *pl. 13, 14*) was issued July 27, 1923.]

being *H. humilis.* Later* he changed the name to *A. decumbens convallarius.* Even at that time, however, he had a misconception of certain species; for, on a later page of the same article, he changed *Astragalus junceus* (Nutt.) Gray to *A. diversifolius roborum* and labeled with this name specimens belonging to *H. campestris.*

Macbride† united *A. campestris* and *A. junceus*, regarding "the relative length of the calyx-lobes and the presence or absence of black pubescence" as "trivial variations" and of "no practical taxonomic value." Perhaps they are so and perhaps *H. campestris, H. junceus* and *H. junciformis* should be only one species, but he has used one of these characters, the longer calyx-lobes, together with the presence of lateral leaflets, as a character to separate his *A. campestris diversifolius* (Gray) Macbr. from the typical form of the species. These characters are just those that characterize the type.

Only two of the specimens cited by Macbride under the variety *diversifolius* are found in New York herbaria: the first of these is Nuttall's, from the "sources of the Platte," Wyoming, which represents the type collection of *H. orthocarpus* Nutt.; and the second is *Baker 242*, from Cedar Edge, Colorado, which matches the type of *H. campestris* in every respect. Evidently Macbride has misinterpreted *A. diversifolius* A. Gray (see below). Of the specimens in the Gray Herbarium, *Canby 84*, from Helena, Montana, is *H. junceus;* so also are *Watson 92* and *Nelson & Macbride 1292*, both from Idaho. The rest represent the typical *H. campestris*, except *Macbride & Payson 3183*, in flower only, from Clyde, Idaho, which may be *H. orthocarpus.* In the herbaria of the New York Botanical Garden and Columbia University, the following specimens of *H. campestris* are found:—

WYOMING: *Nuttall.*

UTAH: Glenwood, *Ward 227;* Hooper, *Leonard 98;* Tropic, *Jones 5312h;* Mandan, *Mulford 118;* Salt Lake City, *Garrett 984;* Pavant Mountains, *Eggleston 10149.*

COLORADO: Cedar Edge, *Baker 242;* Como, *Crandall;* Middle Park, *Patterson;* Glenwood Springs, *Osterhout;* White River, *Mrs. Dun.*

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[*] Contr. W. Bot. **10:** 58. 1902.

[†] Contr. Gray Herb. II. **65:** 35. 1922.

22. HOMALOBUS JUNCEUS Nutt. The duplicate of the type in the Torrey Herbarium is in fruit but shows a white-hairy calyx with very short calyx-lobes and leaves with no or very small lateral leaflets. Sheldon thought that this and *Astragalus diversifolius* represented but one species and applied the latter name to it, as the earlier *A. junceus* was preoccupied by *A. junceus* Ledeb. Since, however, *A. diversifolius* is a synonym of *H. orthocarpus*, *A. junceus*, if transferred to *Astragalus*, would be without a name. This species is much more common than *H. campestris*. I shall therefore not enumerate any specimens. Most of those cited by Macbride under *A. campestris* belong here. Jones, as already noted, named the species *A. diversifolius roborum*.

23. HOMALOBUS JUNCIFORMIS (A. Nels.) Rydb. The status of this species is somewhat problematical, since it has the short calyx-lobes of *H. junceus* and the black-hairiness of *H. campestris*. It is stouter than either, with larger flowers and broader leaflets. Standley regarded it as identical with *H. orthocarpus*, but that species has smaller flowers and a much broader pod. The mature pod of *H. junciformis* is unknown, but the young pod suggests a similarity to that of *H. junceus*. Jones* made *H. junciformis* a synonym of *A. diversifolius*, evidently not being acquainted with the true *A. diversifolius*. The only specimens of *H. junciformis* seen are:—

WYOMING: Fort Steele, *A. Nelson 4839;* Point of Rocks, *A. Nelson 3081;* Leucite Hills, *A. Nelson 4668.*

24. HOMALOBUS ORTHOCARPUS Nutt. The duplicate of the type in the Torrey Herbarium shows only the upper part of the plant, but Nuttall states that the lower leaves bear several leaflets, while the upper are more or less reduced to the rachis. This fact furnished Gray the name *Astragalus diversifolius*, when he found that *A. orthocarpus* was preoccupied by *A. orthocarpus* Boiss. In *H. orthocarpus* the calyx is white-hairy, the lobes are deltoid and not much longer than broad, while the pod is much broader than in the related species, in the duplicate of the type being about 2 cm. long and 4 mm. wide. In the herbarium of the New York Botanical Garden the only specimen like the type is *Goodding 1084* from Juab, Utah, which has been

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* Contr. West. Bot. **10:** 68. 1902.

referred to *A. episcopus* Wats. According to Macbride *A. episcopus* has sessile pods; one might suppose from this that the latter species was a synonym of *H. orthocarpus;* but it is not, since it really has a short-stipitate and glabrous pod. There is also a specimen collected at Salida, Colorado, *Johnston & Hedgecock 634*, which resembles Goodding's very much, but it is in flower only and therefore doubtful. So also is *Macbride & Payson 3183* from Idaho, to which reference has already been made.

25. HOMALOBUS DECUMBENS Nutt. The specimen in the Torrey Herbarium consists of two pieces, a small plant with five attached branches and a single loose branch; the former bears one mature pod and two small racemes in bud; the separate branch bears five immature pods. All the pods are minutely pubescent and decidedly arcuate, and the mature pod is nearly 2.5 cm. long and 3 mm. wide; the calyx lobes are subulate and less than half as long as the tube. The only specimens in the herbarium of the New York Botanical Garden similar to the type are *Hall & Harbour 142*, in part, from Colorado, and *Goodding 1429* from Wood's Creek, Wyoming. The pods of the latter are very young and scarcely show any indication of being arcuate. The specimens in the Gray Herbarium bearing the same number have a better developed pod, and I would refer them to *H. microcarpus.*

A specimen in flower, from Mammoth Hot Springs, Wyoming, named by the collectors *A. decumbens*, viz., *Aven & Elias Nelson 5649*, resembles this species in habit but is more canescent. Macbride has cited this specimen under *A. divergens*, but I rather think that it belongs either here or under *H. tenuifolius* Nutt.

26. HOMALOBUS SEROTINUS (A. Gray) Rydb. Gray described *Astragalus serotinus* as having glabrous or minutely pubescent pods, and Macbride says in his key, "pods glabrous or nearly so." There are three sheets of Cooper's collection in the New York herbaria, and in all three the pods are minutely strigose. The species varies much in the width of the leaves. When they are very narrow the plant resembles much in habit *H. campestris*, but the tip of the keel is always purple and the leaflets more numerous and glabrate above.

WASHINGTON: Okanogan River, *Cooper;* Peshasti, *Sandberg & Leiberg 473;* Loomis, *Griffiths & Cotton 343;* without locality *Vasey 273.*

OREGON: Wallowa County, *Sheldon 8065.*

MONTANA: Big Fork, *Umbach 621.*

ALBERTA: Tunnel Mountain, *McCalla 2134.*

BRITISH COLUMBIA: Nicola Valley, *Dawson 4269.*

27. HOMALOBUS STRIGOSUS (Coult. & Fish.) Rydb. This resembles *H. Palliseri* in habit but differs in the pubescent pod and longer calyx-lobes. Jones* claims that it is the same as *H. serctinus.* It is true that the two resemble each other very much in general appearance, but the calyx-lobes in *H. strigosus* are almost twice as long and the leaves are cinereous on both sides. Macbride regards it as a variety of *H. serotinus.*

ALBERTA: Vermillion Range, *Moodie 1238,* in part.

MONTANA: Park County, *Tweedy;* St. Ignatius Mission, *MacDougal 290;* Columbia Falls, *Williams 1003,* Helena, *Kelsey;* Tobacco Mountain, *Butler;* Deer Lodge River, *Cooper.*

WYOMING: Mammoth Hot Springs, *Mearns 1329;* Alcova, *Goodding 146;*† Sheridan and Buffalo, *Tweedy 3168;* Big Horn, *Tweedy 2355.*

IDAHO: Beaver Canon, *Watson 91;** Howe, *Macbride & Payson 3106,*† in part; Mammoth Hot Springs, *Nelson & Nelson 5648;*† Salmon, *Payson & Payson 1762.*

28. HOMALOBUS TENUIFOLIUS Nutt. The duplicate of Nuttall's type in the Torrey Herbarium is a small plant about 7 cm. high and bears two racemes, one with six flowers and the other with a single pod. The calyx is 2 mm. long, including the lobes, which are about 0.5 mm.; the corolla is about 4 mm. long, and the pod, 14 mm. long and 3 mm. wide, is strigose; the leaflets are narrowly linear-subulate. In the herbarium of the New York Botanical Garden there is only one specimen in fruit like it, *Tweedy 259.* The others are larger and would be referred to *H. decumbens* if they were not so canescent and if the pods were not straight. Gray, as already noted, thought that the species was a depauperate form of *H. campestris.* Coulter and Nelson seem to include it in that species, while Macbride united it with

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* Proc. Calif. Acad. II. **5:** 668. 1895.

† Referred by Macbride to *A. divergens* Blankinship.

A. divergens Blankenship. It would have been more logical to reduce it to a variety of *A. serotinus*. It is not more distinct from that species than *A. strigosus* or *A. Palliseri*. None of the specimens cited by Macbride and seen by me belong to *H. tenuifolius* except *Parry 81* and *A. Nelson 9648*. See under *H. strigosus* and *H. decumbens*.

WYOMING: Rocky Mountains, *Nuttall; Parry 81;* Mount Leidy, *Tweedy 259;* Medicine Bow, *A. Nelson 9648*.

MONTANA: Lima, *Rydberg 2706;* Red Rock, *Shear 5043*.

COLORADO: Lake City, *Pease; Hall & Harbour 142*, in part.

29. HOMALOBUS DIVERGENS (Blankinship) Rydb. In habit the plant resembles the preceding, but the leaflets are much broader and shorter. I have not seen the type, but Blankinship's illustration (except the pod) represents the plant I have in mind. In the original diagnosis the pod is described as stipitate and is so figured. In all the specimens I have seen it is sessile. Blankinship might have had a mixture containing pods of some other species, as for instance the alpine form of *H. Bourgovii*. Not having seen the type, it was not so strange that I, under these circumstances, redescribed the plant as *H. camporum*.* This is the name it would bear, if by chance *Astragalus divergens* should be different from our present conception.

WYOMING: Leckie, *Merrell & Wilcox 537, 585;* Steamboat Mountain, *A. Nelson 7085;* Laramie Hills *198;* Bird's Eye, *Nelson 9559*.

MONTANA: Helena, *Rydberg 2708*.

IDAHO: Beaver Canon, *Rydberg 2707*.

UTAH: Alta, *Jones 1210*.†

30. HOMALOBUS HUMILIS Rydb. Macbride has transferred this to *Astragalus*, under the name *A. Carltonii*, as there was an older *A. humilis* Bieb.

UTAH: Bullion Creek, *Rydberg & Carlton 7147;* Delano Peak, *7219* and *7219a;* Mt. Ellen, *Jones 5670;* Panguitch Lake, *6015n* (this with narrow leaflets).

31. HOMALOBUS OBLONGIFOLIUS Rydb. Macbride regarded this as a variety of *H. hylophilus*. As far as I know the plant

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* Bull. Torrey Club **32:** 666. 1906.

† This Macbride refers to *A. Carltonii* Macbride, i. e. to *H. humilis*, but the pod is that of *H. divergens* and *H. tenuifolius*.

is confined to Colorado. Macbride cites two specimens from Wyoming, *Nelson 869* and *Payson 2068*. The former, as represented in the Columbia University Herbarium is typical *H. hylophilus*, having glabrous pod and broad leaflets. The other number I have not seen.

COLORADO: Cerro Summit, *Baker 409;* Nederlands, *Clokey 3284;* Leadville, *Jones,* Teller, *C. S. Sheldon 108;* Marshall Pass and Leadville, *Jones;* Pinkham Creek, *Goodding 1472,* Delta, *N. F. T. Nelson 181;* without locality, *Parry,* in 1864.

32. HOMALOBUS PAUCIJUGUS Rydb. This resembles *H. tenuifolius* in habit and pod but differs in the few leaflets. As there is an older *Astragalus paucijugus* Schrenk, Macbride renamed my species *A. Garrettii*.

33. HOMALOBUS DECURRENS Rydb. This was also renamed *A. Rydbergii* by Macbride, on account of *A. decurrens* Boiss.

COLORADO: Golden, *Jones 528; Greene;* Estes Park, *Osterhout 2222;* Lake Eldora, *Clokey 3201;* Jefferson County, *3808;* Larimer County, *Osterhout A;* Stove Prairie and Como, *Crandall;* Gray Back, *Rydberg & Vreeland 5960;* Tolland, *Johnston & Hedgecock 664;* without locality, *Hall & Harbour 142,* in part; Central City, *Scovell*.

34. HOMALOBUS MICROCARPUS Rydb. This was reduced by Macbride to a synonym of *A. decumbens*. There would have been more reason for reducing it to, or for making it a variety of, *H. divergens,* since the general habit, the form of the leaflets and the shape of the pod approach that species, but the whole plant is greener, more luxuriant and more erect. One specimen, *Watson 287* from the Uintah Mountains, Utah, may belong here. It has the small pod and the flowers of *H. microcarpus* but is taller, with very long peduncles, 10–14 cm. long, longer leaves, up to 15 cm. long, and more numerous leaflets, the pod is hairy with short black hairs. Macbride erroneously referred the specimen to *Astragalus serotinus* var. *Palliseri,* which has glabrous pods.

COLORADO: east of Rabbit-Ear Range and on the forks of Poudre River and Big South, *Crandall;* Como, *Crandall & Cowen 131;* North Park, *C. F. Baker;* Steamboat Springs, *Osterhout 2774;* Empire, *Tweedy 5642;* without locality, *Hall & Harbour 143; Parry 435*.

WYOMING: Woods Creek, *Goodding 1429.*

35. HOMALOBUS HYLOPHILUS Rydb. This is the most common species of the group in the Northern Rockies, extending as far south as northern Utah and the Black Hills, but not being found in Colorado. Jones* claims that this is a shade form of *A. decumbens convallarius*, due mainly to his misinterpretation of *A. convallarius*, which latter was based on *Homalobus campestris* Nutt.

36. HOMALOBUS PALLISERI (A. Gray) Rydb. Macbride reduced this to a variety, *A. serotinus Palliseri* (Gray) Macbride. It is more closely related to *H. hylophilus*, having the same glabrous pod, but the leaflets are much narrower and the calyx-lobes shorter. There are, however, specimens of *H. hylophilus* which have nearly as narrow leaflets as those of *H. Palliseri.* The Montana specimens of *H. Palliseri* have longer pods and in that respect approach *H. hylophilus.*

ALBERTA: Rocky Mountains, *Bourgeau;* headwaters of the Saskatchewan, *S. Brown 923;* Banff, *S. Brown 80; VanBrunt 6; Canby 41; Barber 105, 279.*

BRITISH COLUMBIA: Carbonate, *Shaw 227, 241;* Green, *3210;* Kettle River, *J. M. Macoun 63152, 63756;* Lake Osoyoos, *70440;* Canmore, *J. Macoun 15;* Maligne River, *Spreadborough 19310;* Armstrong, *E. Nelson 133.*

WASHINGTON: Concomilli, *Griffiths & Cotton 319;* Ophir, *Elmer 528;* Walla Walla, *Brandegee.*

MONTANA: Spanish Basin, *Flodman 636;* Bozeman, *Wilcox 115;* Old Hollowtop, *Rydberg & Bessey 4489;* Bridger Mountains, *4494;* Old Sentinal, *MacDougal 168, 172;* Terminus, *Watson 88.*

37. HOMALOBUS DETRITALIS (M. E. Jones) Rydb. This has been placed in the present group but probably does not belong here. In general habit it resembles the *Simplicifolii*, but the leaves have five leaflets. Whether it has the acute keel-petals characteristic of the *Campestres* or not I do not know, as I did not look for that character when I saw the type some years ago.

E. STENOPHYLLI

Pod glabrous, except the stipe.
  Leaflets narrowly linear.

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* Contr. West. Bot. **10:** 69. 1902.

Leaflets few, the terminal one wanting or continuous with the rachis; calyx-lobes lanceolate, 1.5–2 mm. long. 38. *H. Coltoni.*

Leaflets many, the terminal one present; calyx lobes triangular, 1 mm. long or less.

Leaflets slightly strigose beneath or glabrous throughout. 39. *H. stenophyllus.*

Leaflets strigose-cinereous on both sides.

Stipe of the pod fully half as long as the body, ocrolla ochroleucous or white. 40. *H. MacGregorii.*

Stipe about one third as long as the body; corolla purple. 41. *H. canovirens.*

Leaflets linear-oblong to oval, glabrous above, strigose beneath. 42. *H. Antiselli.*

Pod strigose throughout.

Leaflets linear; raceme elongate lax.

Body of the pod 2–2.5 cm. long abruptly contracted at the base, straight. 43. *H. filipes.*

Body of the pod 2.5–3 cm. long, gradually tapering at each end, slightly arcuate. 44. *H. inversus.*

Leaflets elliptic; raceme short dense. 45. *A. gaviotus.*

38. **Homalobus Coltoni** (M. E. Jones) Rydb. comb. nov.
Astragalus Coltoni M. E. Jones, Zoe **2:** 237. 1891.
Homalobus episcopus Rydb. Bull. Torrey Club **40:** 53, in part. 1913. Not *A. episcopus* S. Wats., 1875.

Astragalus Coltoni was based on specimens from Castle Gate, Utah. It has the habit of *H. junceus* and *H. campestris*, but the pod has a slender stipe, the corolla is purplish, the wings are nearly as long as the banner and the keel is rounded at the apex. It is therefore more closely related to *H. stenophyllus*. I had mistaken it for *H. episcopus* (see my notes under that species on pages 184–5).

UTAH: Castle Gate, *Jones*, in 1890 and 1894; southern Utah, *Bishop*, in 1872.

NEW MEXICO: Carrigo Mountains, *Matthews*, in 1892.

39. HOMALOBUS STENOPHYLLUS (T. & G.) Rydb. This is the best known species of the group and was the first one published, the original name being *Astragalus leptophyllus* Nutt. As that name was preoccupied, *A. stenophyllus* was afterwards substituted. Torrey & Gray suggested that the species might belong in the genus *Homalobus*. The type was collected in flower, and the fruit remained unknown for some time. The type is

perfectly glabrous, except for the more or less black-strigose calyx, but sometimes the upper part of the stem and the lower surface of the leaflets are slightly strigose. This is the case with *S. Watson 283*, which was mistaken for *S. filipes*. Watson's description of that species also applies to *H. stenophyllus*.

BRITISH COLUMBIA: Nicola Valley, *G. M. Dawson 4269*, in 1877; also *J. Macoun*, in 1889.

OREGON: Andrews, *Griffiths & Morris 523;* Hoover Creek, *Leiberg 140;* Juniper Springs, Malheur County *2264;* between Dayville and Mitchell, *Lawrence 1024;* east of Heffner, *582 A;* Blue Mountains, *895;* Burns, *Peck 3029;* without locality, *Nivius*.

IDAHO: Big Willow, Canyon County, *Macbride 161;* Mackay, *1414;* House Creek, *Nelson & Macbride 1761;* Shoshone, *1165;* Martin, *Macbride & Payson 3079;* Reynolds Creek, *Macbride 1029;* Big Butte, *Palmer 240*.

NEVADA: Quinn River Crossing, *Griffiths & Morris 172;* Palisade, *M. E. Jones*, in 1882; Pah-Ute Mountains, *S. Watson 283;* Trucke Pass, *Kenedy 1314;* Alleghany Creek, *Nelson & Macbride 2166;* Reno, *Jones*, in 1897; Montana headwaters of the Missouri, *Wyeth*.

WASHINGTON: Coulee City, *Henderson 2358*.

40. **Homalobus MacGregorii** Rydberg, sp. nov.

A perennial, with a cespitose caudex; stems strigose, striate; lower stipules triangular, scarious, connate, the upper ones more herbaceous, distinct; leaves 5–8 cm. long; leaflets thirteen to nineteen, linear, 10–15 mm. long, 1–2 mm. wide, strigose on both sides; peduncles 1–2 dm. long; racemes lax, 5–12 cm. long; bracts subulate, 2–3 mm. long, calyx strigose, the tube 4–5 mm. long, the teeth triangular, 1 mm. long or less; corolla ochroleucous or white; banner 12 mm. long, obovate; wings 11 mm. long, the blade obliquely oblanceolate, equalling the claw; keel-petals 10 mm. long, rounded at the apex, the blade broadly lunate with a rounded basal auricle; pod stipitate, the stipe 12–15 mm. long, slightly pubescent, the body glabrous, linear-elliptic, acute at each end, 2.5 cm. long, 5–6 mm. broad.

TYPE collected near Frazier Borax Mine, Mount Pinos, Ventura County, California, June 12–14, 1908, *Abrams & McGregor 219* (herbarium of the New York Botanical Garden).

This species is related to *H. stenophyllus* but the stem and leaves are strigose-canescent. It has been mistaken for *H. An-*

tiselli but the leaflets are much narrower and pubescent on both sides. Besides the type, the following specimens belong here.

SOUTHERN CALIFORNIA: Kenworthy, *H. M. Hall 1182;* San Bernadino Mountains, *Parish Brothers 1281.*

LOWER CALIFORNIA: Orcutt, in 1885; *856*, in 1883.

41. HOMALOBUS CONOVIRENS Rydb. *Astragalus Coltoni moabensis* M. E. Jones. This is also related to *H. stenophyllus*, but the leaves and stem are densely grayish strigose, the stipe much shorter, the corolla dark bluish purple.

UTAH: Western slope of La Sal Mountains, *Rydberg & Garrett 8536, 8564;* La Sal Mountains, *Jones*, in 1993.

COLORADO: Naturita, *Payson 336.*

42. **Homalobus Antiselli** (A. Gray) Rydb. comb. nov.

Astragalus Antiselli A. Gray, Bot. Calif. **1**: 152. 1880.

This species differs from the three preceding in the broader leaflets, glabrous above and strigose beneath. *A. Hasseanus* Sheld.* is without doubt the same.

CALIFORNIA: Santa Catalina Island, *Rixford*, in 1914; Sulphur Mountains, *Abrams & McGregor 40;* Santa Inez, *Mrs. Curran*, in 1885; Ventura, *Elmer 3616;* Santa Barbara, *S. F. P.* [*Peckham* ?]; *Torrey 92 bis;* Buenaventura, *Hasse*, in 1888.

43. HOMALOBUS FILIPES (Torr.) Heller. This is very closely related to *H. stenophyllus* and distinguished only by the strigose pod and strigose stem and leaves. The two species have been confused and may not be specifically distinct.

WASHINGTON: Fort Okanogan, *Pickering*, in U. S. Exploring Expedition; Grand Coulee, *Griffiths & Cotton 440;* Ritzville, *Sandberg & Leiberg 163;* Sprague, *Sandberg & Leiberg*, in 1893; Ellenburg, *Piper 2717;* Yakima Region, *Brandegee 732;* Crab Creek, *Saksdorf 281.*

OREGON: Alkali, *T. Howell*, in 1882.

NEVADA: West Humboldt Mountains, *Heller 10631.*

44. **Homalobus inversus** (M. E. Jones) Rydb. comb. nov.

Astragalus inversus M. E. Jones, Zoe. **4**: 276. 1893.

This is closely related to *H. filipes*, differing mostly in the longer, more tapering and slightly curved pod.

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* Minn. Bot. Stud. **1**: 124. 1894.

CALIFORNIA: Susanville, *Brandegee;* same locality, *Jones;* Lava beds, Modoc County, *M. S. Baker*, in 1893.

45. **Homalobus gaviotus** (Elmer) Rydb. comb. nov.

Astragalus gaviotus Elmer, Bot. Gaz. **39**: 54. 1905.

This species is referred with some doubt to this group as the flowers have not been seen. The pod is strigose, nearly straight on the upper suture, the stipe is shorter than in the other species, the raceme is short even in fruit and the leaflets broad.

CALIFORNIA: Gaviota, *Elmer 3759;* same locality, *Eastwood 55* (determined erroneously as *Phaca canescens* Nutt.).

New American Connaraceae

S. F. BLAKE

Connarus megacarpus sp. nov.

Tree; leaflets 7 or 9, elliptic-oblong, 7.2–14.5 cm. long, 3–4.5 cm. wide, emarginate, rounded at base, coriaceous, glabrous above, densely rufid-velvety beneath, short-petioluled; fruits spicate on the rufid-velvety branches of the panicle; follicle densely and persistently rufid-velvety, not striate or wrinkled, the stipe about 8 mm. long, the body 3–3.5 cm. long, 2–2.3 cm. wide, the beak stout, 2–4 mm. long.

Petiole (3.5–4.5 cm. long) and rachis (6–12.5 cm. long) stout, terete, persistently cinereous-velutinous; petiolules similar, 2–3 mm. long; leaflets elliptic-oblong or slightly elliptic-obovate, short-pointed with emarginate apex, rounded and emarginulate at base, narrowly revolute-margined, brownish-green and shining above, densely and closely rufid- or ochroleucous-velvety on whole surface beneath, the lateral veins about 7 pairs, arcuate-joined near margin, prominulous beneath, scarcely so above, the secondaries obscurely reticulate beneath, the costa impressed above, prominent beneath; panicles about 13 cm. long, about as broad, the flowers sessile; calyx (persistent at base of fruit) rufid-velvety, 4 mm. long; fruiting follicle solitary, the body obovate-oval, glabrous inside, stout-apiculate at apex of the straight side; seed 2 cm. long, 1 cm. wide, the aril about 9 mm. long.

BRITISH GUIANA: abundant along the Demarara River, November 25, 1913, *C. D. Mell* (type in U. S. National Herbarium, No. 694130).

Similar in most characters to *Connarus suberosus* Planch. and *C. Perrottetii* (DC.) Planch., but both these species have fruits not over 2 cm. long.

Rourea adenophora sp. nov.

Small tree or vine; leaflets 3–7, elliptic to oval or oval-ovate, 2.5–13 cm. long, caudate-acuminate, rounded at base, firmly pergamentaceous, shining and densely prominulous-reticulate on both sides, puberulous on the costa on both sides and on the chief veins beneath, otherwise glabrous; panicles densely stipitate-glandular and puberulous; flowers small; sepals broadly ovate to suborbicular; follicle solitary, glabrous, 1.2–1.6 cm. long.

Branches puberulous, glabrate, the younger purplish brown; petiole (2.5–4.5 cm. long) and rachis (2.2–5.5 cm. long) rather densely spreading-puberulous, often with short glandular hairs intermixed; petiolules 2–4 mm. long; leaflets chiefly elliptic, the caudate tip about 3–12 mm. long, obtuse, the lateral leaflets (decreasing in size toward base of leaf) 2.5–10.2 cm. long, 1.3–4.5 cm. wide, the terminal leaflet 8.5–13 cm. long, 3.5–5 cm. wide, the chief lateral veins 4 to 6 pairs; panicles thyrsoid, 9–10 cm. long, the bracts minute, lanceolate, about 1 mm. long, the branches 5–10-flowered, the pedicels slender, 2–3 mm. long, jointed near base; calyx lobes (in submature flowers) 5, imbricate, the outer broadly ovate or suborbicular-ovate, acutish or acute, the inner suborbicular, obtuse or rounded, 1.5–2 mm. long, 1.5–1.8 mm. wide, about twice as long as the tube, stipitate-glandular, ciliolate, and especially toward apex puberulous; petals (submature) oval, obtuse, equaling the calyx lobes; stamens 10, glabrous, the filaments dilated and connate at base; carpels 5, sparsely pilose; calyx in fruit accrescent, 4 mm. long, the lobes oval or oval-ovate, firm; fruit sessile, included at base by the calyx, curved, glabrous, obscurely striatulate; seed 1 cm. long; aril 3 mm. long.

PANAMA: woods between Gatun and Lion Hill, Canal Zone, altitude 10–20 meters, January 26, 1911, *H. Pittier 2566* (type in U. S. National Herbarium, No. 676722); forests around Puerto Remedios, Chiriquí, altitude 10–30 meters, March 31, 1911, *H. Pittier 3380*.

According to Mr. Pittier's notes, No. 2566 was a vine with yellowish green flowers, and No. 3380 a small tree with red fruit. The species is related to *R. glabra* H. B. K., but is easily distinguished by its densely stipitate-glandular and puberulous panicles. In fruit the glands are for the most part deciduous, although the hairs persist.

Rourea Pittieri sp. nov.

Vine; branches densely griseous-pilosulous, glabrate; leaflets 5 or 7, oval or the lower suborbicular-ovate, 5–11.5 cm. long, 3–6.7 cm. wide, short-acuminate, rounded at base, pergamentaceous, densely prominulous-reticulate on both sides, shining above and puberulous on the costa, otherwise glabrous, paler or glaucescent beneath and rather densely spreading-pilosulous with dull hairs on all the veins and veinlets or on the whole surface; panicles pyramidal, branched usually from the base, densely griseous-pilosulous with spreading hairs; pedicels 4–5 mm. long; calyx 3.5–4 mm. long, densely griseous-pilosulous, the lobes ovate; petals 4.5 mm. long; follicle glabrous, striatulate, about 1.4 cm. long.

Petiole (2.2–8 cm. long) and rachis (3.5–8 cm. long) densely griseous-puberulous, glabrescent; petiolules 2–4 mm. long; leaflets oval or the lower sometimes suborbicular-ovate, the lateral 5–11 cm. long, 3–6 cm. wide, the terminal 9–11.5 cm. long, 5–6.7 cm. wide, the extreme apex obtuse, the chief lateral veins about 6 pairs; panicles 8–16 cm. long (including peduncle), the bracts minute, about 1 mm. long, the branches erectish or spreading, few- to many-flowered, the pedicels jointed near the base; calyx lobes erect, broadly ovate, 3 mm. long, 2 mm. wide, about three times as long as the tube, the outer acute or subacuminate, the inner obtuse or rounded; petals obovate, obtuse, erect, 4.5 mm. long, 2.2 mm. wide; filaments slender above the connate bases, the longer stamens about equaling the petals; carpels densely pilose; fruiting calyx somewhat accrescent, firm, 4.5–5 mm. long, enclosing the base of the fruit, the latter very slightly curved; seed 1 cm. long.

PANAMA: foothills of Garagará, Sambú Basin, southern Darién, altitude 30–500 meters, February, 1912, *H. Pittier 5613* (type in U. S. National Herbarium, No. 715887); in forests, Loma de La Gloría, near Fató (Nombre de Dios), Province of Colón, altitude 10–104 meters, August 23, 1911, *H. Pittier 4247*.

No. 4247 is said to be a vine with yellowish flowers. The species is well distinguished by the griseous pubescence of the panicles, lower leaf surface, and calyx, and by the long pedicels.

Two new species of Cuscuta from Peru

T. G. YUNCKER

(WITH TWO TEXT FIGURES)

Cuscuta lucidicarpa sp. nov.

Stems slender. Flowers 3–4 mm. long, more or less papillate, subsessile or sessile, borne singly or in few-flowered clusters; calyx mostly red, scarcely enclosing the corolla tube, divided to the middle; lobes triangular-ovate, obtuse, scarcely, or not at all, overlapping; corolla campanulate or somewhat globular; lobes reddish, triangular-ovate, acutish, connivent or spreading; anthers oval and subsessile on short, stout filaments; scales reaching the stamens or slightly shorter, oblong, fringed with short processes, bridged low; styles subulate and tapering from the conical ovary. Capsule depressed-globose, becoming very thin and semi-transparent, circumscissile, carrying the withered corolla about its upper part; seeds four, triangular, hilum short.

This species belongs in subsection SUBULATAE near *Cuscuta boliviana* Yuncker from which it differs in its shorter filaments, more subulate styles and in not having overlapping or carinate calyx lobes.

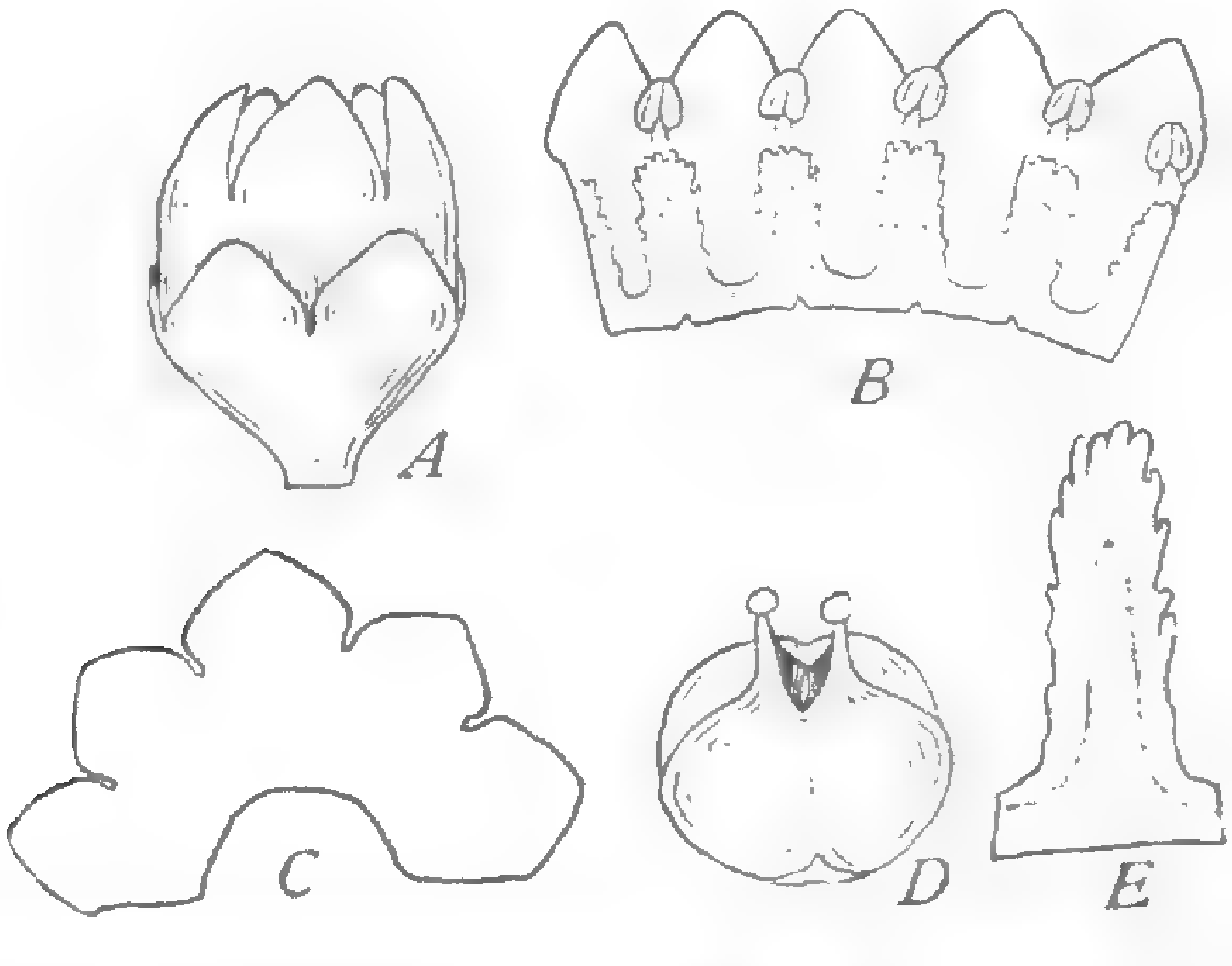

FIG. 1. CUSCUTA LUCIDICARPA Yuncker. A. Flower, × 5. B. Opened corolla, × 5. C. Opened calyx, × 5. D. Capsule, × 5. E. Individual scale, × 10.

Collected by McBride and Featherstone (*No. 1035*) at Tarma, Peru, June 1–6, 1922. The type is in the Field Museum Herbarium (sheet No. 517, 559); a duplicate is in the author's herbarium.

Cuscuta rubella sp. nov.

Stems slender. Flowers 2–2.5 mm. long, sessile, in dense, small, few-flowered glomerules; calyx red, somewhat fleshy, shorter than the corolla tube, deeply divided and loose about the corolla; lobes more or less uneven, oval, obovate or sometimes spatulate, obtuse; corolla reddish in the exposed part, more or less globular, furrowed along the stamen attachments, papillate in the lower part of the tube; lobes shorter than the tube, triangular, acute, upright or spreading; anthers large, oval, subsessile on very short filaments, or sessile; scales reaching the anthers, narrowly oblong, fringed with few, short processes, bridged low; subulate styles tapering from the ovary giving it a conical appearance. Mature capsules not seen but evidently they would be circumscissile and carry the withered corolla about them.

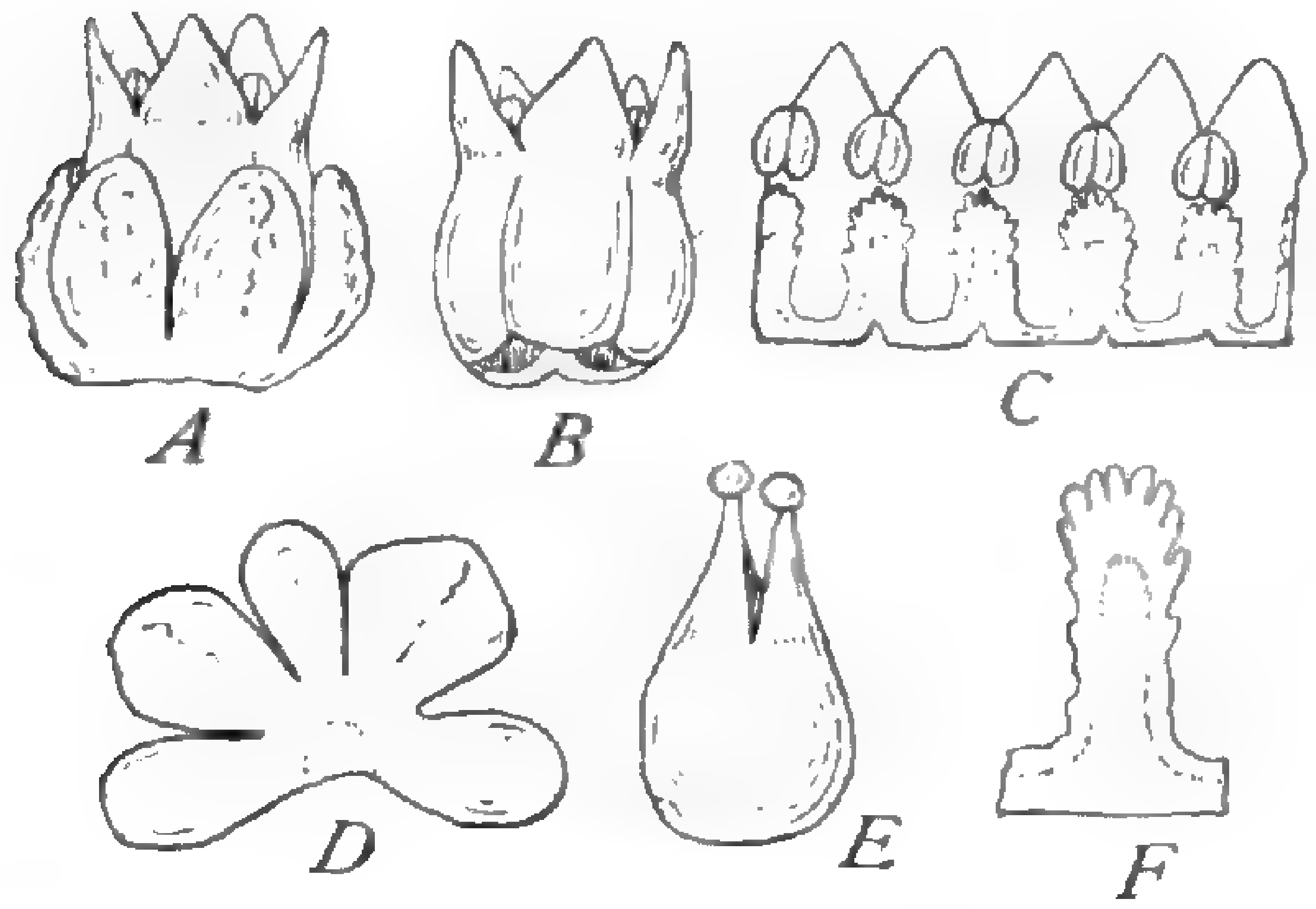

FIG. 2. CUSCUTA RUBELLA Yuncker. A. Flower, × 5. B. Corolla, × 5. C. Opened corolla, × 5. D. Opened calyx, × 5. E. Ovary, × 5. F. Individual scale, × 10.

The flowers of this species are very attractive with their red calyxes and corollas and bright yellow anthers. It is closely allied with the foregoing species, but differs in having smaller, sessile flowers with fleshy, deeply divided calyxes and with oval, obovate or spatulate calyx lobes.

Collected by McBride and Featherstone (*No. 371*) at Matucana, Peru, April 12–May 3, 1922. The type is in the Field Museum Herbarium (sheet No. 516,906); a duplicate is in the author's herbarium.

DEPAUW UNIVERSITY

INDEX TO AMERICAN BOTANICAL LITERATURE

1915-1922

The aim of this Index is to include all current botanical literature written by Americans, published in America, or based upon American material; the word America being used in the broadest sense.

Reviews, and papers that relate exclusively to forestry, agriculture, horticulture, manufactured products of vegetable origin, or laboratory methods are not included, and no attempt is made to index the literature of bacteriology. An occasional exception is made in favor of some paper appearing in an American periodical which is devoted wholly to botany. Reprints are not mentioned unless they differ from the original in some important particular. If users of the Index will call the attention of the editor to errors or omissions, their kindness will be appreciated.

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Anderson, M. Detection of overgrazing by means of indicator-plants. Trans. Utah Acad. Sci. **2:** 56–58. 1921.

Arber, E. A. N. Devonian floras. Pp. 1–xlv + 1–100. *f. 1–47.* Cambridge [England]. 1921.

A study of the origin of Cormophyta.

Baez, J. R. Breve noticia sobre la vegetación de los departamentos Parana y Diamante (Entre Rios [Argentina]). Bol. Minist. Agr. Nac. [Argentina] **27:** 465–475. S 1922.

Belyea, H. C. A suggestion for forest regions and forest types as a basis of management in New York State. Jour. For. **20:** 854–868. D 1922. [With map.]

Bitter, G. *Polylepis, Margyricarpus.* In Herzog, T., Die von Dr. Th. Herzog auf seiner zweiten Reise durch Bolivien in den Jahren 1910 und 1911 gesammelten Pflanzen,—VI. Meded. Rijk's Herb. Leiden **46:** 2, 3. 1922.

Bower, F. O. The primitive spindle as a fundamental feature in the embryology of plants. Proc. Roy. Soc. Edinburgh **43:** 1–36. *f. 1–26.* 4 N 1922.

Britton, E. G. Holly, laurel and winterberry. Jour. N. Y. Bot. Gard. **23**: 177–181. D 1922.

Carleton, M. A. Note on the *Fusarium* wilt disease of bananas. Science II. **56**: 663, 664. 8 D 1922.

Chaney, R. W. The flora of the Eagle Creek formation. Contrib. Walker Mus. **2**: 115–182. *pl. 5–22.* Jl 1920.

Czartkowski, A. Nouvelles recherches sur la formation de l'anthocyane chez *Tradescantia viridis.* Compt. Rend. Soc. Sci. Varsovie **8**: 866, 867. D 1915.

Davis, B. M. An attempt to improve through selection the style-length and fertility of *Oenothera brevistylis.* Genetics **7**: 590–596. N 1922.

Eyster, W. H. Inheritance of zigzag culms in maize. Genetics **7**: 559–567. N 1922.

Eyster, W. H. The intensity for linkage between the factors for sugary endosperm and for tunicate ears [of maize] and the relative frequency of their crossing over in microspore and megaspore development. Genetics **7**: 597–601. N 1922.

Fitzpatrick, H. M. Edible and poisonous mushrooms: hints to the collector. Cornell Rural School Leafl. **16**: 93–101. S 1922. [Illust.]

Fürth, P. Zur Biologie und Mikrochemie einiger *Pirola*-Arten. Sitzungsber. Akad. Wissensch. Wien Abt. 1. **129**: 559–588. *pl. 1.* 1920.

Garcia, A. Cartilla objectiva. Pp. 1–164. Popayan, Colombia. D 1919.

Contains accounts of many economic and other plants.

Garrett, A. O. Forest tree diseases [of Utah]. Trans. Utah Acad. Sci. **2**: 182–189. 1921.

Girola, C. D. Enfermedades del tomate en Argentina:—Podredumbre apical (*Fusarium* sp.), Antracnosis (*Colletotrichum phomoides* Sacc.) y Peronospora (*Phytophthora infestans* De Bary). Bol. Minist. Agr. Nac. [Argentina] **27**: 503–505. S 1922. [Illust.]

Guilliermond, A. Nouvelles observations cytologiques sur les Saprolegniacées. Cellule **32:** 429–454. *pl. 1–3.* 1922.

Hallier, H. *Condalia.* In Herzog, T., Die von Dr. Th. Herzog auf seiner zweiten Reise durch Bolivien in den Jahren 1910 und 1911 gesammelten Pflanzen,—VI. Meded. Rijk's Herb. Leiden **64:** 9. 1922.

Hallier, H. Convolvulaceae. In Herzog, von T., Die von Dr. Th. Herzog auf seiner zweiten Reise durch Bolivien in den Jahren 1910 und 1911 gesammelten Pflanzen,—VI. Meded. Rijk's Herb. Leiden **46:** 12.

Harms, H. Über zwei neue Arten der Gattung *Malesherbia* aus Peru. Notizbl. Bot. Gart. u. Mus. Berlin-Dahlem **8:** 209–212. 1 Jl 1922.

Malesherbia angustisecta and *M. haemantha*, spp. nov.

Hartwig, K. G. *Populus canadensis* und *Populus monilifera* Aiton. Mitteil. Deutsch. Dendr. Ges. **1922:** 170–172. 1922. [Illust.]

Heald, F. D. Some suggestions for teaching mycology. Trans. Am. Micr. Soc. **41:** 175–178. O 1922.

Henrard, J. T. *Paspalum hydrophylum* spec. nov. aus Paraguay. Meded. Rijk's Herb. Leiden **45:** 1, 2. 1922. [Illust.]

Henrard, J. T. Two new grasses from Paraguay. Meded. Rijk's Herb. Leiden **47:** 1–4. 1922. [Illust.]

Paspalum plumosum and *P. caaguazuense*, spp. nov.

Herrera, F. Las Cactaceas del departamento del Cuzco [Peru] (*cont.*). Arch. Asoc. Peruana Progr. Ci. **2:** 68–73. *pl. 1–6.* 1922.

[Herzog, T.] Die von Dr. Th. Herzog auf seiner zweiten Reise durch Bolivien in den Jahren 1910 und 1911 gesammelten Pflanzen. VI. Meded. Rijk's Herb. Leiden **46:** 1–31. 1922.

Includes *Enneatypus* and *Wernhamia*, gen. nov., and new species in *Ruprechtia* (1), *Alternanthera* (2), *Gomphrena* (1), *Tournefortia* (1), *Psychotria* (1), *Borreria* (3).

Huber, B. Zur Biologie der Torfmoororchidee *Liparis Loeselii* Rich. Sitzungsber. Akad. Wissensch. Wien Abt. 1. **130:** 307–328. *pl. 1.* 1921.

Irmscher, E. Pflanzenverbreitung und Entwicklung der Kontinente. Mitteil. Institut. Allg. Bot. Hamburg **5:** 17–235. 1922.

Jones, C. Common forest trees of Virginia. Virginia Geol. Commission Office State For. Bull. 26: 1–64. Au 1922.

Juday, C. Limnological observations on Lake George [New York]. In Needham, J. G., *et al.*, A biological survey of Lake George, N. Y. 37–51. 1922.

Jung, M. J. Über den Nachweis und die Verbreitung des Chlors im Pflanzenreiche. Sitzungsber. Akad. Wissensch. Wien Abt. 1. **129:** 297–340. *pl. 1.* 1920.

Kirstein, K. Sero-diagnostische Untersuchungen uber die Verwandschaften innerhalb der Pflanzengruppe der Gymnospermae. Bot. Archiv. **2:** 57–79. 15 Au 1922.

Klein, G. Studien über das Anthochlor. Sitzungsber. Akad. Wissensch. Wien Abt. 1. **129:** 341–396. *pl. 1.* 1920.

Korstian, C. F. Evaporation and soil moisture in relation to forest planting. Trans. Utah Acad. Sci. **2:** 116, 117. 1921.

Korstian, C. F. Relation of precipitation to height growth of forest tree saplings. Trans. Utah Acad. Sci. **2:** 260–268. 1921.

Korstian, C. F., & Long, W. H. The western yellow pine mistletoe: Effect on growth and suggestions for control. U. S. Dept. Agr. Bull. 1112: 1–35. *pl. 1–5.* 21 O 1922.

Kränzlin, F. Über einige Orchideen. In Mitteliungen aus dem Herbar des Instituts für allgemeine Botanik. Mitteil. Institut. Allg. Bot. Hamburg **5:** 236–240. 1922.

Krause, K. Loranthaceae peruvianae novae. Notizbl. Bot. Gart. u. Mus. Berlin-Dahlem **8:** 206–208. 1 Jl 1922.

New species in *Aetanthus* (1) and *Psittacanthus* (2).

Vol. 50 No. 9

BULLETIN

OF THE

TORREY BOTANICAL CLUB

SEPTEMBER, 1923

The altitudinal distribution of plants on Mt. Gedeh, Java*

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(WITH PLATES 15–17 AND SEVEN TEXT FIGURES)

Mt. Gedeh is in the "Preanger Regent" of western Java. At its foot lies the village of Singdanglaja, some five hours' journey by rail and coach from Buitenzorg. Gedeh, with Pangerango, the "princely mountain," and Sela, form a trio of volcanic mountain peaks. Of these Gedeh alone is semi-active. It was last in eruption in 1899. At present the hot springs gush-

FIG. 1. Mt. Pangerango from Gedeh. The slope of Pangerango makes clear how rapid a change in altitude plants have to contend with. Water covered rice fields can be faintly seen in the valley just over the lower edge of Pangerango.

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[*] Contribution from the Osborn Botanical Laboratory.

[The BULLETIN for August (50: 261–282) was issued August 17, 1923.]

ing from the mountain side and the several fumaroles in the crater emitting fumes of sulphur are the only indications that Mt. Gedeh is a volcano in the dormant state. Mt. Pangerango (FIG. 1), whose beautiful conical form commands admiration, and Mt. Sela are both extinct. The botanical explorations described on the following pages refer primarily to Mt. Gedeh, though some mention is made of plants of interest found on the two neighboring peaks.

Midway up the slope of Mt. Gedeh is the government experimental station of Tjibodas ("white river"). The laboratory, cottage, and garden at Tjibodas serve as a base for botanical excursions into the mountain forests beyond. The Tjibodas Garden contains numerous interesting plants, notably the renowned grass trees, *Xanthorrhoea Preissii* (PLATE 15, FIG. 1). These liliaceous trees are natives of the Australian savannahs. The twin specimens in the Tjibodas Garden are familiar to botanists through the illustration in Haberlandt's "Botanische Tropenreise." The trees have doubled in size since Haberlandt saw them thirty years ago.

FIG. 2. The superb rasamala, *Altingia excelsa*. This tree (in the center background) is 150 feet high. Note the straight uniform trunk. The tree-fern is an *Alsophila*, 42 feet high.

Back of Tjibodas, extending to the summits of Mts. Gedeh, Pangerango, and Sela, is a virgin forest of supreme beauty, with a flora unsurpassed, if indeed it is approached, by that of any other similar region in the world. One of the most striking features of plant life in this mountain rain-forest is the marked change in type of vegetation as one ascends. At Tjibodas, at an altitude of 4,600 feet, the palms, bamboos, fig trees, and bananas, characteristic of the lowlands, still occur, but are soon displaced by oaks, chestnuts, *Podocarpus* and tree-ferns. Gnarled, moss-covered trees then follow, only later to disappear. And finally, after attaining an altitude of 9,400 feet, a scant alpine flora, characterized by the Javanese edelweiss, is reached.

The following brief description of the altitudinal distribution of plants in the virgin forest on Mt. Gedeh will, I trust, give some idea of the distribution of the plant life and of its luxuriance and beauty.

Java was divided into four "Gewächszonen" by Junghuhn, the foremost naturalist of the Dutch East Indies, and these vegetative zones he divided into "Gebiete." The first zone of Junghuhn is the hot region from the sea-coast to an altitude of 2,000 feet; the second, the temperate region from 2,000 to 4,500 feet; the third, the cool region from 4,500 to 7,500 feet; and the fourth, the cold region from 7,500 to 10,000 feet. These last two vegetative zones of Junghuhn, from 4,600 feet, the altitude of Tjibodas, to 9,400 feet, the crater of Mt. Gedeh,* which are the ones that concern us here, can be divided into five distinct subzones.

I. THE RASAMALA SUBZONE

(4,600–5,500 feet)

The first subzone, at Tjibodas, is characterized by its big trees—superb giants many of them are. The monarch of all is the rasamala, *Altingia excelsa* (*Liquidambar Altingiana*) (FIG. 2), whose smooth, grayish white trunk arises out of the wealth of vegetation at its base as straight as a ship's mast. These fine trees reach a height of 175 feet and a maximum diameter, near the base, of 8 feet (FIG. 3). When buttresses are formed the base may flare to a diameter of 12 feet. The trunk maintains a diameter of fully 2½ feet for 75 to 100 feet from the ground at which point it first branches. So characteristic a tree of this region is *Altingia* that it may well lend its name to the subzone.

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* The summit of Mt. Pangerango is 9,800 feet.

The rivals of the rasamala in size are the oaks and chestnuts. The oaks, of which there are several species (e.g., *Quercus spicata* and *Q. Pseudo-molucca*), are in some respects strikingly different from our American oaks. The trunks rise like great columns before they branch to form the crown, and the fruits are of a colossal size compared to an American acorn. Botanists do not always appreciate how characteristic a tree of the tropics the oak is. We become accustomed to regarding *Quercus* as a temperate genus. The chestnuts are likewise of great size. The two characteristic species are *Castanea Tungurrut* and *C. argentea*.

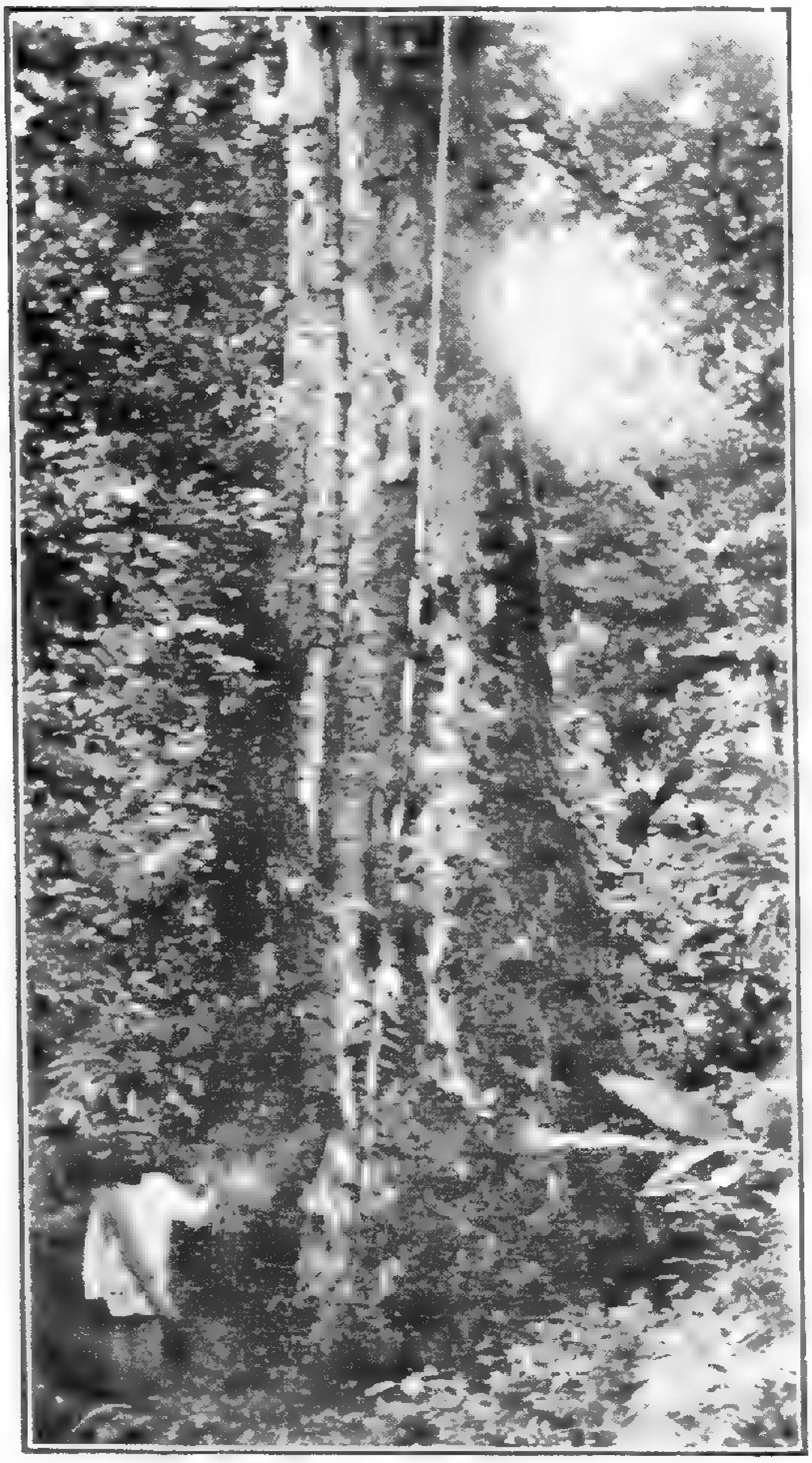

FIG. 3. The trunk-base of the rasamala. The large liane (on the left), marked with successive rings, is a *Piper*, possibly *P. baccatum*. The smaller liane, extending up the trunk, is *Ficus disticha*. The large leaves of a banana, *Musa acuminata*, can be seen in the lower right corner.

Conspicuous among the big trees of the first subzone on Mt. Gedeh are the figs, whose composite trunks assume tremendous size. There are nine species of fig on Gedeh (more than sixty in all Java), the largest of which is *Ficus involucrata*. In connection with the epiphytic habit of fig tree seedlings it is of interest to note that Chodat,* as a result of his recent investigations in South America, has discovered that "the young *Ficus* from its first implantation behaves as a *saprophyte*."

The medium sized and smaller trees of the first subzone are

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* Chodat, Robert: La Végétation du Paraguay, Geneva, 1920.

of many kinds. There are numerous species of *Eugenia* and *Litsea*, three of *Viburnum*, two of *Turpinia*, and one each of *Euonymus* (*E. javanicus*), *Ilex* (*I. spicata*), and *Olea* (*O. javanica*). The small tree *Pithecolobium montanum* is one of the few Leguminosae to be found in these mountain forests. We shall meet a second tree member of this family on the very summit of Gedeh. Another tree of this and the second subzone which is worthy of special note is *Vernonia arborea*. This tree is one of the Compositae, yet it may be 80 feet high and 2½ feet in diameter (FIG. 4).

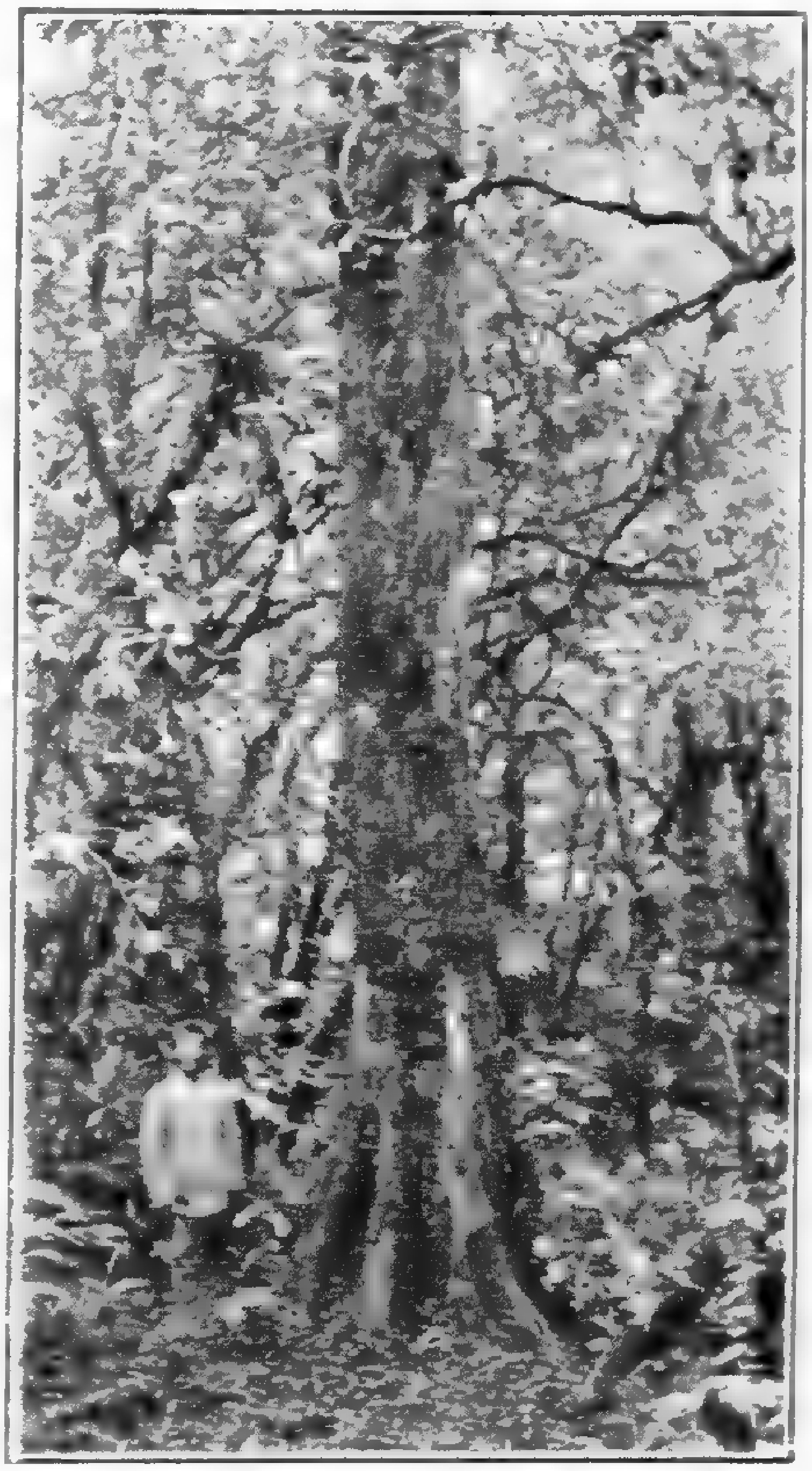

FIG. 4. The trunk of *Vernonia arborea*. This 80 foot tree is one of the Compositae.

The fig, *Ficus Ribes*, is an interesting small tree because it affords a striking example of a rather common fruiting habit among tropical trees, namely, cauliflory. *Saurauja* (*S. pendula*, *S. nudiflora*, and five other species), whose white flowers with thick, waxy petals are often seen strewn over the path, is an example of incomplete cauliflory. The flowers are borne not only on the surface of the tree trunk and larger limbs but at the tips of slender twigs as well. Such a semi-cauliflory characterizes several other Javanese trees.

The foregoing list of first subzone trees is very incomplete and gives at best but a number of representative species. Of trees alone there are nearly two hundred species on Mt. Gedeh; of shrubs and herbs over three hundred and fifty species; and of lianes some sixty or more, totaling at least six hundred species of plants exclusive of the ferns, mosses and fungi.

Lianes are numerous in the first subzone. The family Vitaceae is well represented among the smaller climbers

The slender and warty vine, *Vitis papillosa,* is of interest because of its multitude of aerial roots which often swing clear for fifty feet or more from the crown of some huge tree and present a striking picture when one comes upon a barricade of them lighted up by the sun. *Smilax odoratissima* is the catbrier of these forests. *Agalmyla parasitica* (which is *not* parasitic) is an interesting epiphytic climber frequently met with. The tubular flowers are of a brilliant scarlet with long protruding stamens of purple. The leaves of this vine when in the cool of the shade project outward perpendicularly to the support, but droop once the sun strikes them. The petioles and leaves are thick, succulent, and turgid, suggesting the mechanism by which the raising and lowering of the leaves is accomplished. Another creeper found frequently upon the trunks of trees is the aroid, *Scindapsus hederaceus,* readily distinguished by its broad, winged petioles. This vine and its sister genus *Rhaphidophora* are the only two climbing Araceae found in any great abundance in the mountain rain-forest. Among the large lianes are *Uncaria* and *Embelia* (*E. pergamacea*), the latter often attaining great length (as much as 250 feet).

So numerous are the plants that make up the undergrowth of the first subzone that it is an almost hopeless task to attempt to give a representative list of them. A single bamboo, *Dinochloa scandens,* is still to be found at this altitude. Of the many palms which characterize the tropical vegetation of Java as a whole, but three comparatively inconspicuous genera occur in the mountain forest. These are the slender and graceful *Pinanga Kuhlii* and the two rattan palms, *Calamus* and *Plectocomia* (*P. elongata*). The two latter genera are climbing palms with long extended leaf rhachides armed with vicious recurved thorns by means of which the plants often attain a height of 75 feet or more, thus reaching up into the second story of the forest. One of the Pandanaceae, *Pandanus Lais,* is very common in the undergrowth of the first subzone.

Showy flowers are much more abundant at Tjibodas than is usually the case in a tropical rain-forest, although less frequent in the forest interior. They seek the bright areas along the trail and the open formations of the higher zones. In the closed formation of the first subzone the most striking flower is that of the ginger, *Amomum.* Its brilliant scarlet blossom is often found protruding from the ground, growing quite alone in the very center of the trail. Dense thickets are formed by the rank growth of the tall vegetative shoots of this plant. Associated with this ginger is another species, *Phaeomeria solaris*, whose flower also appears just above the surface of the soil some distance from the leafy shoots of the plant The blossom is of a rich orange-red color and as large as a small head of cabbage. Other but terminal-flowered gingers will be met with in the next subzone. The blossom of *Arisaema filiforme* (a jack-in-the-pulpit) is an attractive though somber colored flower, especially interesting because of its unusually long spadix which droops out of the spathe to a length of eight inches. The three jaunty bells of the tiny weed, *Argostemma montanum*, form a dainty white flower cluster which is abundant along the trail. *Cestrum elegans* is a small tree-shrub with red pendent flowers.

Of the phanerogamous epiphytes the orchids are the most numerous. Those most frequently met with are species of *Dendrobium* and *Bulbophyllum*. *Liparis*, *Eria*, and *Appendicula* are somewhat less numerous, although *A. ramosa* is rather abundant. Certain species of *Dendrobium* are remarkable because all the individuals in any one locality blossom simultaneously.* The epiphytic "pines," *Tillandsia* and *Caruguata*, which are so striking and characteristic a feature of the epiphytic vegetation of tropical America, are not to be found in Java—indeed, not in all the eastern tropics.

Ferns, both as part of the vegetation of the forest floor and as epiphytes are exceedingly abundant. The ferns as a group are widely distributed throughout the mountain rain-forest, occurring in all subzones, though in varying abundance. Common terrestrial forms of the first subzone are, *Pteridium aquilinum*, *Pteris longipes*, numerous species of *Dryopteris* (e.g., *D. truncata*), and the interesting *Diplazium proliferum*, which develops a bud, often of huge size, at the base of each pinna. This habit of proliferating is not infrequent among the ferns of this region.

A noteworthy fern is the enormous *Angiopteris evecta*, found in moist spots, especially bordering streams, and occurring in many forms. This fern commands attention because of its colossal 15–18 foot fronds which spread out over the trail.

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* See Seifriz, William: The gregarious flowering of the orchid *Dendrobium crumenatum*. Am. Jour. Bot. **20**: 32–37. 1923.

Another interesting fern is the stout *Polypodium Feei*, with its mass of prominent sori completely covering the back of a fertile frond. It grows in great profusion among the rocks near the base of waterfalls. A variety of this same fern—a most adaptable and widely distributed species—is again found on the dry lava floor of the crater of Mt. Gedeh.

Tree-ferns are infrequently met with along the trail in the lower subzones. They seek the more open forest formations at higher altitudes or the sunny yet moist ravines.

The epiphytic ferns with the tree-ferns distinguish a tropical fern flora from a temperate one. The characteristic epiphytic fern of the first subzone on Mt. Gedeh is the magnificent bird's nest fern, *Asplenium nidus* (PLATE 15, FIG. 2). This huge fern, with a spread of sometimes as much as 15 feet, may be seen perched like a large bird with out-spread wings, upon a small limb far out in space, or it may be found near the ground completely encircling a tree trunk, then resembling a fancy flower basket. Occasionally one is seen apparently floating free in the air, and only on close examination is the bent slender twig supporting it discovered (PLATE 16, FIG. 1).

The nest shape of *Asplenium nidus* forms an ideal catch-all for falling leaves and detritus, a natural basket always full of rich organic matter. This fine substratum in turn supports yet other epiphytic ferns. Some of these are of very good size, such as *Stenolepsis tristis* and *Nephrolepsis acuminata*, with fronds often 6–8 feet in length (PLATE 16, FIG. 1). This latter fern is one of the most graceful in the forest.

While *Asplenium nidus* is the characteristic fern and epiphyte of the first subzone, other epiphytic ferns are numerous. Chief among these is *Polypodium Heracleum*, a rival in size though not in abundance of *Asplenium nidus*. The large, deeply cleft fronds of the *Polypodium*, measuring as much as 7 feet in length and 18 inches in width, surround a tree very much as does the bird's nest fern. This remarkable genus is the only one which has representative species in all the subzones, from Tjibodas to the crater of Gedeh.

The long grass-like fern *Vittaria elongata* drapes the trees and lianes in an attractive manner (FIG. 3). Several polypodiums, e.g., *P. obliquatum*, are common as epiphytes. And one should not neglect the less conspicuous but beautiful and delicate little filmy ferns, species of *Hymenophyllum* and *Trichomanes*. The smallest of the hymenophyllums we shall find at a higher altitude.

Mosses exist, but are to be found in much greater abundance in the second and fourth subzones. Species of liverworts are not numerous, although fine patches of the large *Dumortiera hirsuta* are frequent.

Fungi (with conspicuous fruits) are seldom met with. This is rather generally true of the tropics. A few species of the woody and leathery forms of the Polyporaceae and an occasional gill fungus are all that are superficially evident. Diligent search does, however, reveal other and interesting species, often of brilliant color.

Of lichens the number of species is exceedingly great. I have seen trunks of the great rasamala completely covered with encrusting lichens which give to the tree the appearance of an elaborate mosaic. The Graphidae are especially attractive. One feels that nature must have some story to tell in their queer markings if one but knew the key. Indeed, they look every bit as intelligible as the hieroglyphics of the Malay language. Forty-seven species of lichens were collected from the first subzone. The genera *Graphis*, *Pertusaria*, and *Sticta* are especially well represented.*

II. THE PODOCARPUS SUBZONE

(5,500–7,000 feet)

At an altitude of about 5,500 feet there is a pronounced change in the general appearance of the mountain forest. One realizes immediately that the woods have assumed a different dress. Everything is moss-covered (PLATE 16, FIG. 2). It is surprising with what suddenness the transformation takes place, and one wonders what differences in climatic factors can exist which produce so marked and so sudden a change between the region just left and that which lies beyond. So profuse is the moss drapery that one is inclined to term this the moss zone. Such a designation would, however, be inaccurate, as subsequent investigation will show.

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* For a full account of the lichens and mosses collected in the Tjibodas forest see, The altitudinal distribution of lichens and mosses on Mt. Gedeh, Java, to be published in The Ecologist, January, 1924.

Here, in the second subzone, which we have just entered, the vegetation first really assumes the aspect of a tropical rainforest. Lianes are more numerous. The undergrowth is less orderly (but by no means a "jungle," a word which is so often and so erroneously used to characterize tropical vegetation). Trees, rocks, and soil are moss-bedecked; and all is reeking wet, actual bogs being met with under foot.

FIG. 5. The monarch of the second subzone, *Podocarpus imbricatus*. The vine on the trunk some 20 feet from the ground is *Epipremnum pinnatum*. The native shown is Sapiin, the veteran plant collector of Tjibodas, who knows the Sundanese name of every seed-plant in these mountain forests.

Some plant forms of the first subzone are still abundant, but others are no longer seen and new forms take their place. The great rasamala is rare. *Podocarpus* is its successor (FIG. 5). This tree is the only conifer, in fact the only gymnosperm, indigenous to Mt. Gedeh. Three species of *Podocarpus* are to be found, *P. imbricata* (*P. cupressina*), *P. neriifolia*, and *P. amara*. While this genus extends into the two adjacent zones, especially the upper one, it is in this second subzone that it is most abundant and reaches its maximum size, fully 5 feet in diameter.

Podocarpus is the monarch of the second subzone, as was *Altingia* of the first,, but other very large trees are also numerous. Especially fine is *Engelhardtia* (*E. serrata* and *E. spicata*). This big tree resembles the rasamala in size and shape, but its small lanceolate leaflets give to its lofty crown a different and lacy appearance. Another large tree common to this and the adjoining third subzone is *Schima Noronhae*, the "poespa" of the Javanese. Its good-sized, showy flowers are often seen sprinkling the ground with spots of white and yellow. The figs, oaks, and chestnuts are still present and of great size. One repeatedly stops to admire the huge, tall, straight trunks of these superb giants of the mountain forest.

The small trees of the second subzone include *Meliosma nervosa*, *Elaeocarpus Acronodia* (and four other species of this genus), *Michelia montana* of the magnolia family, *Macropanax dispermum* of the Araliaceae, and *Pygeum latifolium*, a rosaceous tree (PLATE 16, FIG. 2).

Lianes are abundant. A conspicuous climber is the spiny *Fagara scandens*, one of the Rutaceae. The huge stubby spines tipped with sharp thorns give to this vine a vicious appearance. Isolated specimens of the climbing aroid *Epipremnum pinnatum* are met with.

Of epiphytes, the beautiful bird's nest fern, *Asplenium nidus*, still flourishes. The climbing pandanaceous epiphyte *Freycinetia* is first met here. The smaller epiphytes of this second subzone are chiefly orchids, ferns and mosses. An attractive orchid frequently seen in *Schoenorchis juncifolia*, with long, drooping stems and spindling, awl-shaped leaves, resembling a *Freycinetia* in miniature.

The forest floor assumes quite a different aspect in the second subzone owing to a greater abundance of light. Tropical forests are not as dark as most people who have never visited them believe; indeed, more light penetrates a tropical mountain rain-forest than enters a temperate closed deciduous forest, and a great deal more than reaches the ground in a Maine pine wood. The forest canopy of the second subzone is an open one. Trees are fewer than in the first subzone and the undergrowth flourishes proportionately better.

The rattan and Pinango palms are more numerous here at 6,000 feet than they were a thousand feet lower. Numerous species of Zingiberaceae are present. The two first subzone gingers, *Amomum* and *Phaeomeria solaris*, are still frequently met with. The coarse weed, *Cyrtandra repens*, with large, white, tubular flowers is widely spread in this as it is in the two adjoining subzones.

Terrestrial ferns grow in great luxuriance (PLATE 16, FIG. 2). *Polypodium nigrescens* is an interesting example which immediately attracts attention not only because of itshuge, coarse fronds but because of the exceedingly prominent sori which, when seen on the dorsal side of the frond, are at first suspected of being insect galls. Another interesting species of fern is the epiphytic climber, *Oleandra neriiformis*, whose sprawling fronds reach far out from the tree trunk on which they grow somewhat in the manner of the epiphytic *Freycinetia*. The slender, hairy *Polypodium setigerum* is a graceful epiphytic fern. But to give a representative list of the ferns to be found in a Javan mountain forest would be a tremendous task.

Lycopodiums and selaginellas are likewise numerous. *Lycopodium Phlegmaria* is an interesting epiphytic species looking, with its tiny lanceolate leaves, more like a phanerogamous creeper than a member of the Pteridophyta.

The epiphytic growth of bryophytes is luxuriant. Every tree is moss-bedecked (PLATE 16, FIG. 2). The most abundant and typical festooning moss of the second subzone is *Papillaria fuscescens*, readily distinguished by its long, pendent streamers and small alternate "leaves" standing out at right angles to the stem. The moss *Mniodendron divaricatum* is a constant companion under foot from the first to the third subzone. Its little upright shoots, resembling miniature palms, are scattered over the ground and rocks along the trail until the highest altitudes are reached. Occurring epiphytically with the profuse growth is one of the many species of the liverwort *Plagiochila* (e.g., *P. Belangeriana*). A small terrestrial hepatic is *Fimbriaria Zollingeri*.

Very few lichens are to be found in this moss-covered zone, though a few gelatinous species are present. The absence of lichens is probably due, in part, to the moderate amount of light which penetrates the interior of this subzone, and, in part, to lack of space upon which to grow. They are crowded out by the widespread mossy covering.

As the upper limits of the second subzone are reached the giant specimens of *Podocarpus*, *Engelhardtia*, and *Schima* are no longer to be found. Only relatively small examples of these genera are now present (PLATE 16, FIG. 2). The average diameter of trees in the upper half of the second subzone is not over 12 inches as compared with diameters of 5 feet (*Podocarpus*) and 4 feet (*Engelhardtia*) in the first half of the zone.

As the border line between the second and third subzones is reached small bogs are not infrequent. Growing in these one may find the pitcher plant, *Nepenthes melamphora*, with brilliant, purplish red, pendent pitchers. One wonders why a plant such as *Nepenthes* occurs in a locality so poor in insect life as the upper mountain regions of these forests. The pitcher of *Nepenthes* is a nicely planned mechanism for attracting, catching, and digesting insects, but of little use in the high altitudes of the third subzone where insect life is sparse. When the pitchers of *Nepenthes* are emptied they are found to contain but few and only small insects. As the plant thrives wonderfully well, an organic diet appears unnecessary. A further point of interest in connection with *Nepenthes* is the extreme polymorphism of the species. In the bogs where the plant is met with under foot in the third subzone, it is of a very compact form not rising over 8 inches from the ground. In other and drier regions of this zone *Nepenthes* occurs as a liane reaching a maximum length of 25 feet. The tendrils are extended leaf midribs. On the vines few, sometimes no, pitchers are formed. Numerous transitional forms occur between the two extreme types.

III. THE HERBACEOUS SUBZONE

(7,000–8,000 feet)

The transition from the second to the third subzone is gradual. The change in type of vegetation with increase in altitude is noticeable throughout the second subzone, the upper limits of which begin to assume third subzone characters. The epiphytic pandanaceous *Freycinetia* and the tall herb *Strobilanthes cernuus*, typical third subzone species, begin to appear in the upper limits of the second subzone, while second subzone genera, such as *Podocarpus* and the bird's nest fern, *Asplenium nidus*, last far into the third subzone.

The third subzone is open in character. The undergrowth, therefore, receives more light. Being at a high altitude the zone is frequently enveloped in clouds, and being, further, just below the gap between Gedeh and Pangerango, it is protected from wind. The zone is, consequently, very moist. Abundant light and moisture permit a luxuriant flora of tender herbs.

The trees of the third subzone are not distinctive. The open forest formation is made up of tree genera which are characteristic of the two neighboring zones. The second zone genera *Quercus* and *Schima* are abundant, and *Podocarpus* occurs occasionally. The high altitude trees *Symplocos*, *Polyosma*, *Astronia*, and *Rapanea* first make their appearance here.

The most characteristic liane and epiphyte of the third subzone is the climbing *Freycinetia*. This grotesque plant, of which there are two species on Gedeh, is widely distributed. Sometimes only a single leafy shoot reaches far out into space. More often a number of sprawling branches hang over the trail like so many ferocious dragons blocking the way. Frequently the growth is so dense as to form a solid mass 15–20 feet in diameter high up on a tree trunk.

But it is the herbaceous undergrowth which characterizes the third subzone. Areas exist which are literally flower gardens. Several species of *Impatiens* are very abundant. The exquisite, pansy-like blossoms of these plants are found in delicate shades of pink and purple. The most common species is the pink-flowered *I. platypetala*. Frequently the purple-spotted pink flowers of *I. cyclocoma* are seen, and also the white, purple-centered blossoms of *I. hirsuta*. Less abundant is *I. choneceras* with a white flower, from which projects a short spur.

The liliaceous *Disporum chinense* (*D. pullum*), first cousin to the American Solomon's seal (*Polygonatum*), with dangling purple bells, is common in the undergrowth of this flowery zone. One of the commonest blossoms is the slender white, tubular flower of *Ophiorrhiza longiflora* (Rubiaceae). Begonias (e.g., *B. isoptera*) are very numerous, likewise the urticaceous herb *Elatostemma*. This latter plant is interesting because of the force with which the male flowers open. When a male bud (the species is monoecious) opens, the stamens fly back one at a time with great suddenness and force, scattering the pollen in a miniature cloud; indeed, the generic name tells the story, "stamen hurler."

Strobilanthes cernuus is a tall, succulent herb forming dense thickets in the second as well as the third subzone. The native name is "bobokuan" ("boku," articulation). It is a most unattractive, rank weed, but its flowers are exquisite little things. They are very small, shaped like tiny rose buds. The petals are white, pencilled along their outer edge with brilliant green.

The presence of one of the gingers, *Hedychium coronarium*, is first noted by its sweet perfume, scenting the air from far. *Curculigo curvata*, of the *Amaryllis* family, forms nearly pure stands in the undergrowth. A large yellow raspberry, *Rubus alpestris*, tempts one to taste it only to find that it is frightfully sour.

The notch between the peaks of Gedeh and Pangerango, where the third subzone ends at an altitude of nearly 8,000 feet, is the home of one of the most exquisite of all tropical plants, the tree fern. The tree fern, although always associated with the tropics, is in reality subtropical. It is not found with such truly tropical plants as the cocoanut. On the contrary, it occurs at relatively high altitudes, where the temperature is moderate. As a group, the ferns are generally regarded as shade loving plants, but I am inclined to believe that it is not their apparent shade loving proclivities which determine the regions in which ferns in general

FIG. 6. The crown of an *Alsophila*.

thrive, but rather their moisture requirements. The tree fern, for good development, requires *abundant* light as well as ample moisture and a cool temperature. Specimens found in the dark interior of the mountain rain-forests are invariably poor, and never have I seen a good stand of tree ferns but that the crowns were above all the surrounding vegetation, exposed to direct sunlight.

In the gulch at Kandang Badak, where the above mentioned climatic conditions prevail, there is an excellent growth of tree ferns. *Alsophila glauca* var. *densa* and *Cyathea orientalis* are the two characteristic tall species. The genus *Dicksonia*, which does not exceed a height of 10 feet as compared with a maximum of 50 feet for the other two genera, is represented by a single species, *D. Blumei*. When well developed the crown of the tree fern represents the most beautiful and delicate of all tropical foliage (FIG. 6).

Gleichenia, like the tree fern, requires ample light for its best development, but is an exception among ferns in that it thrives well in very dry soil. This fern is usually found in exposed sunny localities. Thus, it is very abundant in the open formation of the third subzone, where two species are common, a small, wiry one, *G. linearis*, and a large, coarse species, *G. volubilis*, which often sends out prostrate leafless shoots as much as 20 feet in length. Both form impenetrable thickets.

Mosses are much less abundant here in the third subzone than they were in the second. Their absence is due probably to the open, sunny, and therefore less moist nature of this region. Lichens, on the other hand, are more numerous. The cosmopolitan *Usnea* occurs in great abundance. This lichen is typically, the world over, a genus of high altitudes or latitudes.

The evidence that Mt. Gedeh is not a dead volcano is to be had along the trail in the third subzone, where two springs of steaming hot water gush forth and give rise to the brook "Tjipanas."* In the extremely hot water (about 130° F.)† of these springs there grows in great luxuriance a species of the

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*"Tji" is a Malay prefix signifying "river". "Panas" the newcomer soon adds to his vocabulary; it means "hot".

†One often reads of higher temperatures of springs in which plants are growing, but the maximum temperature from a reliable source is not over 65° C. (150° F.).

alga *Oscillatoria*, which forms a jelly-like mass, rather resembling blubber, some two inches in thickness. Only the surface layer of this mass is green.

IV. THE VACCINIUM SUBZONE

(8,000–9,000 feet)

The climb to the crater of Mt. Gedeh or to the summit of Mt. Pangerango is made in about two hours from the cabin at Kandang Badak situated in the notch between the two peaks. The transition from the third to the fourth subzones is very abrupt on Gedeh and Pangerango. Tree ferns grow in great abundance almost to the very ridge at the notch where the third subzone ends. Above this point no tree fern is again met with. *Castanea*, *Quercus*, and *Engelhardtia*, among the big trees of the lower subzones, and persisting as smaller trees to the very edge of the fourth subzone, are now no longer seen. *Podocarpus* and *Schima Noronhae* are still present, but in reduced size, and greatly in the minority as compared with the other species. With change in kind there takes place a pronounced change in size and form of the trees. The maximum height here is not over sixty feet, and while some gnarled trunk may be more than a foot through, the average diameter of the trees is but 8 inches. Especially noticeable is the irregular shape of the trees of this zone (PLATE 17, FIGS. 1, 2). Whether the gnarled and twisted form of high altitude trees is due to the purely mechanical effect of wind or to trying physiological conditions such as high evaporation and low light intensity, under which the plants must grow, is still an unsettled question.

The characteristic genus of the fourth subzone is *Vaccinium*. In the upper half of the zone it forms pure stands (PLATE 17, FIG. 2), but in the lower half other typical high altitude trees are present. Among these are, *Polyosma ilicifolia*, *Astronia spectabilis*, *Symplocos sessilifolia*, *Weinmannia*, *Eurya japonica*, and *Rapanea avenis*, the last a typically high altitude tree resembling *Vaccinium*. The type of leaves of the last two genera is an instance of a very common characteristic of alpine plants, namely, the reduced size, leathery texture, and waxy surface of the leaves.

A tree of unusual interest, occurring near the summit of Mt. Sela, is the maple *Acer niveum*, which attains a maximum height of 100 feet. It is the only maple in Java.

Among the large lianes at this altitude are *Vaccinium varingiaefolium*, (*V. Teysmanni*), *Lonicera Loureiri*, and *Schefflera lutescens*.

The genus *Vaccinium* is remarkable because of extreme polymorphism; it exists as a tree, shrub, or liane, and may be either terrestrial or epiphytic. Five species occur on Mt. Gedeh: *V. varingiaefolium*, *V. coriàceum*, *V. lucidum*, *V. laurifolium*, and *V. ellipticum*. *V. varingiaefolium* is the most polymorphic of them all. It may be shrub, tree or liane and may grow terrestrially or epiphytically. As a liane it was formerly known as *V. Teysmanni*. In this form it is found in the lower half of the fourth subzone (PLATE 17, FIG. 1). In the upper section of the zone it occurs only as a tree to the almost complete exclusion of all other tree species. So far as I am aware botanical science is totally ignorant of the cause of such polymorphism. In the case of the pitcher plant *Nepenthes*, a conceivable factor is moisture, since the dwarf form is found in bogs and the liane form grows on dry soil. The same factor may possibly play a part in determining the form of *Vaccinium varingiaefolium*, since the liane is found only in the relatively moist lower half of the fourth subzone, while in the much drier upper section the species occurs as a tree. *Schefflera lutescens* may also occur as tree or liane.

The shrub *Rhododendron* is very abundant in this open, high altitude forest. There are three species: *R. retusum* with red flowers, *R. cilium* with large yellow flowers, and *R. javanicum* (the most common) with very large, orange-red flowers. This last species is especially interesting because of its presence here at 9,000 feet as a terrestrial shrub, although equally abundant as an epiphyte at Tjibodas 4,000 feet lower.

Herbs of the third subzone types are still numerous in this higher region. Especially noticeable is the blue color of flowers and fruits. Very prominent are the cobalt and pale green blues. The berries of the shrub *Lasianthus lucidus*, a rubiaceous plant, are of the former color, while the clusters of berries of *Dichroa febrifuga*, one of the Saxifragaceae, are a rich dark blue. The flowers of this plant are of a striking pale blue color. But the finest of the blue flowers is that of the orchid *Dendrobium Hasseltii*. Indeed, while I am inclined to give first place to *Impatiens platypetala* as the most beautiful of all the mountain flowers, *Dendrobium Hasseltii* holds a close second place. This orchid is quite common in these high, foggy regions.

The parasite *Balanophora elongata* is a curious plant. The only aerial portion is the thick, short, flower-spike of brick-red color. *Balanophora* grows parasitically on the roots of *Vaccinium* and *Albizzia*, the latter a tree whose acquaintance we shall soon make. The subterranean portion of the parasite is a mixture of host and parasite tissue. This composite tissue is very hard and much resembles a piece of stag horn coral.

Terrestrial ferns are less numerous at this altitude. *Polystichum biaristatum* and *Plagiogyria glauca* are the most common. The coarse *Lomaria vestita* forms pure patches. *Nephrodium tuberosum* (*N. hirsutum*) is worthy of special note because of its large root tubercles. The epiphytic ferns are more numerous, especially species of *Polypodium*—for example, *P. obliquatum*, the smaller *P. hirtellum*, the climbing *P. rupestris*, and the smallest of polypodies, *P. cucullatum*. The thick, leathery, 15 inch leaves of *Elaphoglossum* one would hardly suspect as being those of a fern. Among the "filmy" ferns is the tiniest of all ferns, *Hymenophyllum paniculiflorum*, whose delicate lacy frond measures less than an inch in length. The lycopodium, *L. volubile*, is very prolific at this altitude.

Mosses are again exceedingly abundant in the lower half of the fourth subzone. Every tree and vine is covered with a thick mat of reeking wet moss (PLATE 17, FIG. 1). That is, there is here a second "moss zone." It is evident that "moss zone," which has been used by ecologists as a descriptive term in connection with mountain rain-forest regions, may be inaccurate.

The mosses of the fourth and second subzones differ strikingly in type. Those of the second subzone are mostly festooning types, loose in form, growing in long, pendent streamers. In the higher and more windy fourth subzone the mosses are all of a compact, tufted type, well adapted to hold water. A comparison of the two photographs, PLATE 16, FIG. 2, and PLATE 17, FIG. 1, will help visualize the pronounced difference in moss type of these two zones. An enumeration of genera would further emphasize the marked altitudinal distribution of mosses on Mt. Gedeh. Of thirty-two species collected and identified no species and only two genera are common to both the second and the fourth subzones.

The fourth subzone extends to the summit of Pangerango with no pronounced change in type of vegetation, except at the very top where there is a small alpine plant community, barely more than an acre in area. The plants of this little alpine garden consist of shrubs, herbs, and grasses. Of shrubs there are dwarf *Vaccinium*, *Rapanea*, *Eurya*, and *Gaultheria*. The fruit of the bush *Vaccinium* resembles that of the American blueberry, and, though edible, is insipid.

Among the flowers of this small alpine pasture one of the prettiest is *Hypericum Leschenaultii*, much resembling the evening primrose of American pastures. Another reminder of fields at home is the buttercup, *Ranunculus javanicus*. Then there is a dandelion-like plant, *Sonchus asper*, the pale blue violet *Viola serpens*, the weed *Plantago major*, and a wild strawberry. Indeed, one could well imagine himself in a New England pasture. The small yellow, tubular flower of *Primula imperialis* deserves mention because it was singled out by the Dutch naturalist Junghuhn as "Queen among all the herbs which inhabit the summits of the mountains." So exalted a position for *Primula imperialis* is hardly deserved when *Impatiens platypetala* is near.

The view from the summit of Pangerango is one of the finest in all Java. Water-covered rice fields, one of the most charming and characteristic features of oriental tropical agriculture, lie close to the mountain base (FIG. 1), and beyond groves of cocoanut palms are distinguishable. Other mountain peaks stand silhouetted against the soft color of the morning sky. One is looking over the "Preanger Regent," the most picturesque province of all Java.

The trail to the crater of Mt. Gedeh differs from that to the summit of Mt. Pangerango, just described, in two striking particulars: first, the fourth subzone of Gedeh is divided into halves, distinguished by several prominent characteristics; and second, there is on Gedeh a fifth subzone of considerable area with a very distinctive flora.

The trees of the lower half of the fourth subzone on Gedeh are covered with a profuse growth of moss. Thick, water-soaked wads of moss pad every trunk. Suddenly, about midway in the zone, the moss covering disappears, and the trees are bedecked with lichens instead. An idea of the completeness of the change can be had by comparing the photographs on PLATE 17.

Both sections of this high altitude subzone receive ample precipitation, but the upper half is considerably more open in character and more wind-swept. The complete absence of mosses in the upper part of the zone is probably due to the effect of dessicating winds at the higher altitude, where even compact, tufted mosses would be unable to retain moisture. The presence of lichens in the upper half of the zone and their absence in the lower section is possibly due, in part, to better illumination and, in part, to lack of mosses in the upper region. Certain it is that the profuse moss covering of the lower half of the subzone leaves no spot where a lichen might subsist.

Having reached a second lichen flora it is instructive to compare the lichens found at the higher altitude with those of the first subzone at Tjibodas. Of sixty-seven species of lichens collected none are common to both the first and the fourth subzones, with one possible exception. Among the fourth subzone lichens are four species of *Parmelia*, a *Phaeographis*, and a *Cetraria* (*Nephromopsis*); the latter is the most common lichen at this altitude, growing luxuriantly in large, fluffy, cream-colored patches.

V. THE EDELWEISS SUBZONE

(9,400 feet)

On emerging from the last stand of trees which ends the fourth subzone on Mt. Gedeh (PLATE 17, FIG. 2), quite a different type of vegetation confronts one. Plant life is sparse. Only one genus of tree exists and it averages not over 12 feet in height. The two characteristic plants of the alpine flora of the fifth subzone are the shrub, *Anaphalis javanica* (one of the Compositae), and the small tree *Albizzia montana* (FIG. 7). The former, with flowers of soft grayish-white color, is the edelweiss of Java. Other plants typical of this open alpine formation on the lava floor of the old crater of Gedeh are the crinkly leaved tree-shrub *Myrica javanica*, the dwarf *Rhododendron*, the dwarf *Vaccinium varingiaefolium*, and the shrub *Gaultheria leucocarpa* with tiny pale pink flowers, white berries, and leaves of a pronounced and very agreeable winter-green odor when crushed. The leaves of *Gaultheria* exhibit a characteristic of alpine plants, standing perpendicularly to and closely surrounding the stem. Some few ferns are still found at this altitude, and lycopodiums are quite abundant, for example, *L. gedeanum*.

This fifth subzone is essentially the last distinctive vegetative region on Mt. Gedeh. There is, however, a small area immediately surrounding the present crater of Gedeh and extending a short distance down into the crater, which can be regarded as an upper subdivision of the fifth subzone, for here the plants are fewer in number and all greatly dwarfed. The vegetation which is scattered over this waste surface of lava consists of isolated and small stunted specimens of edelweiss, *Vaccinium*, *Rhododendron*, *Myrica*, and another *Gaultheria* species, *G. fragrantissima*.

FIG. 7. The Javanese edelweiss, *Anaphalis javanica*. The foliage in the right background is that of a young *Albizzia montana*. The tiny leaves in the left center background are *Myrica javanica*. The shrubs in front of the edelweiss, center and left, are dwarf *Vaccinium varingiaefolium*.

Of the multifarious ferns ubiquitously present from the first to the fifth subzone, only one, a dwarf variety of the remarkably adaptable species, *Polypodium Feei*, remains to occupy the rocky lava floor of the old crater of Gedeh. Representatives of this genus are found in every zone from an altitude of 4,600 to one of 9,400 feet.

Within the confines of the huge old crater of Gedeh there occurs, in addition to the present semi-active crater, another small, secondary but extinct crater which harbors a flora all its own. This little plant community owes its existence to its well protected situation and to the abundance of water which drains into it from the summit of Gedeh. Here, on the bottom of the small crater pit, there is a rank growth of the sedge, *Gahnia javanica*, scattered in the form of huge hillocks.

There is probably no tropical mountain rain-forest in the world which possesses a greater wealth of plant life than that at Tjibodas on Mt. Gedeh. I can imagine no walk more delightful and full of interest than from the laboratory at Tjibodas to the crater of Gedeh and the summit of Pangerango. The Tjibodas virgin forest, as compared with other similar regions, presents an outstanding diversity of vegetative types. While, in certain respects, the flora of Java is surpassed by that of Ceylon, and by the vegetation in certain parts of India, in neither case, nor anywhere in the tropics, so far as my knowledge extends, is there within so limited and so readily accessible a region such a multiplicity of genera and such extremes of plant forms—a thousand or more species—from bananas to edelweiss.

I wish to express my indebtedness to Dr. C. A. Backer of the Buitenzorg Herbarium for his kindness in identifying many plants collected by me. Without Dr. Backer's generous assistance so complete a description of the vegetative zones as is here given would not have been possible.

Description of plates 15-17

PLATE 15

FIG. 1 (at left). The grass trees, *Xanthorrhoea Preissii*, in the Tjibodas Garden. These liliaceous trees are natives of the Australian savannahs.

FIG. 2 (at right). The stately bird's nest fern, *Asplenium nidus.*

PLATE 16

FIG. 1 (at left). An *Asplenium nidus* suspended at the end of a slender branch. Note other epiphytic ferns growing out of the base of the *Asplenium.*

FIG. 2 (at right). The upper limits of the second subzone. The larger trees (the maximum size at this altitude) are *Engelhardtia.* The smaller trees are *Pygeum*, *Elaeocarpus*, *Meliosma*, and *Schefflera.* *Disporum* is abundant on the forest floor (lower right corner). The terrestrial ferns are chiefly *Dryopteris heterocarpa.* *Asplenium caudatum* is the (epiphytic) fern with long slender fronds to the right of the coolie. One of the most abundant mosses in the profuse epiphytic moss growth is *Papillaria fuscescens*, the typical festooning moss of the second subzone.

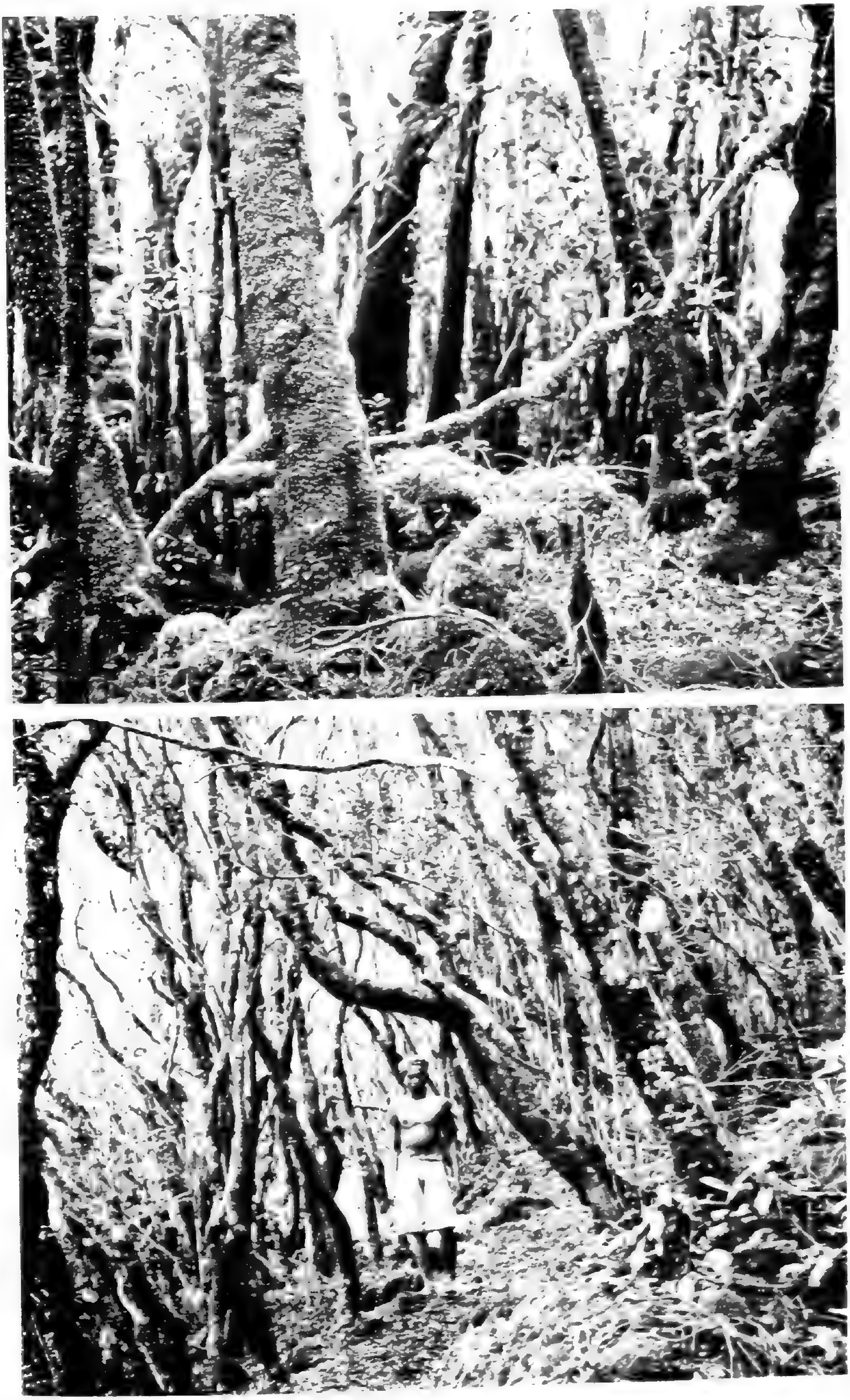
PLATE 17

FIG. 1 (above). The moss section of the fourth subzone. The largest tree (left center) is *Schima Noronhae.* The smaller trees are *Polyosma*, *Symplocos*, and *Rapanea.* The liane is *Vaccinium varingiaefolium* (*V. Teysmanni*). Few *Vaccinium* trees are to be found in the lower half of this zone. Note the thick padding of moss. The moss covering the large tree is *Sematophyllum pinnatum.* Suspended from the liane are the tiny epiphytic ferns, *Polypodium cucullatum* and *Hymenophyllum paniculiflorum.*

FIG. 2 (below). The lichen section of the fourth subzone. Note the complete absence of moss. This is the last stand of trees on Mt. Gedeh. The trees are almost entirely *Vaccinium varingiaefolium*, the same species which grows as a liane a few hundred feet lower (see FIG. 1).

SEIFRIZ: PLANTS ON MT. GEDEH, JAVA

SEIFRIZ: PLANTS ON MT. GEDEH, JAVA



SEIFRIZ: PLANTS ON MT. GEDEH, JAVA

Studies in tropical Ascomycetes—II. An interesting Xylaria from Porto Rico

Fred J. Seaver

(with plate 18)

During a recent collecting trip to Porto Rico* the writer had the opportunity of visiting one of the most interesting and fruitful collecting grounds for fungi to be found on the island, the Luquillo Mountains. This trip was made possible through the efforts of Mr. E. M. Bruner, Forester of Porto Rico, who placed at our disposal the Forest Ranger's cabins, located at an elevation of about 1200 feet. This camp consisted of two cabins, one of boards with metal roof and the other a rough building with thatched roof. The cabins were provided with cots, utensils, and charcoal stoves for cooking. Mr. Bruner acted as host and supervised the house-keeping activities during our stay here. The party consisted of Dr. and Mrs. Britton, Mr. Bruner, Professor Dale of the University of Porto Rico, and the writer.

The trip from San Juan to Mameyes was made by automobile and the ascent from this point to the Forester's camp on foot or by horse. Arriving at the camp soon after noon on Friday, February 23, the remainder of the afternoon was spent in the vicinity of the camp site.

Saturday, February 24, an expedition was planned to the top of El Yunque, for a long time supposed to be the highest peak in Porto Rico but now known to be exceeded by several others. The ascent was made much easier by reason of the trail of broken stone which had been constructed under the supervision of Mr. Bruner for a greater part of the distance. Soon after the expedition started, it began to rain, as it nearly always does at this elevation, and a slow drizzle continued during the remainder of the day, making the climb at places very slippery and disagreeable. We succeeded, however, in reaching the top

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* Jour. of the New York Bot. Gard. **25**: 99–101. 1923.

at an elevation of about 3500 feet. Here the soil and atmosphere were saturated so much so that it was impossible to find a dry place where one could sit to rest or eat. The trunks of the trees and even the leaves were loaded with mosses and hepatics, and there seemed to be scarcely room for a fungus to grow, although a number of specimens of *Aschersonia* in fruit (*Hypocrella*) were found and in some abundance.

The view, which must be remarkable under favorable conditions, was entirely missed by us on account of the atmospheric conditions. In spite of the fact that we were under the tropical sun, had it not been obscured by the clouds and fog, a cold chill wind swept over the mountain top which compelled us to look for a sheltered spot where we could eat our lunch in comparative comfort.

Not finding the conditions especially favorable for mycological collecting at this elevation the writer preceded the party down the trail in order to have time to hunt leisurely for things of a mycological nature. Many interesting collections were made, most of which have not been studied critically. One which was of more than usual interest was a species of *Xylaria* which is made the subject of the present paper. These specimens were found opposite the overhanging rock about midway between the summit and the Forester's cabin to the left of the trail going down.

On account of the density of the forest and the general gloominess of the day it was difficult to detect the presence of minute fungi. However, on picking up what appeared to be a dead stick a seed the size of an ordinary marble was found attached to its base. On closer examination the object, which proved to be a large fungus, was at first thought to be a fine *Cordyceps*. It finally turned out to be a *Xylaria*. On further search other plants were found until fifty or a hundred specimens had been collected, each growing from a seed of what proved to be that of the mountain palm, *Euterpe globosa* Gaert. A number of fungi, such as certain species of *Sclerotinia*, grow exclusively on seeds. Also a number of species of *Cordyceps* grow on underground fungi which have much the same general appearance, but so far as the experience of the writer has gone this is the only species of *Xylaria* encountered which has the general appearance of a *Cordyceps* with the habitat of the *Sclerotinia*.

The species has been found only in the one locality in Porto Rico. The host on which the fungus preys, however, occurs from Cuba to Hispaniola and Porto Rico and in the Lesser Antilles from Saba to Grenada. Assuming that the fungus is restricted to the one host, as it seems to be, its possible range of distribution then is as indicated above. The only economic bearing which the fungus could have is in connection with the destruction of the seeds of the host. How important this can be cannot be stated.

Our material from Porto Rico agrees quite closely, so far as we can judge from the description, with *Xylaria palmicola* Winter,* described from Brazil. No specimens of the South American species have been seen and the host of that species is not named. The fact that the host of the Porto Rican species does not occur in South America, so far as we know, leads the writer to regard ours as distinct. The species is dedicated to Mr. Bruner and a description appended.

Xylaria Bruneriana, sp. nov.

Stromata growing upon and their mycelium filling the seeds of their host and apparently absorbing the greater part of their contents, reaching a height of 10–12 cm. and a diameter of 2–4 mm., consisting of a sterile stem and a fertile club-shaped head, the latter comprising about one fourth of the whole stroma and considerably thicker; stem cylindrical, slightly tapering above and becoming twisted (especially when dried); perithecia subglobose, about 500 μ in diameter; asci subcylindric, eight-spored, reaching a length of 140 μ, the ascus wall being very transparent and often almost invisible; spores unequal-sided, rather sharp pointed, 16 × 6–7 μ, often slightly flattened, hyaline, becoming dark brown.

On fallen seeds of the mountain palm, *Euterpe globosa* Gaert., El Yunque, February 24, 1923.

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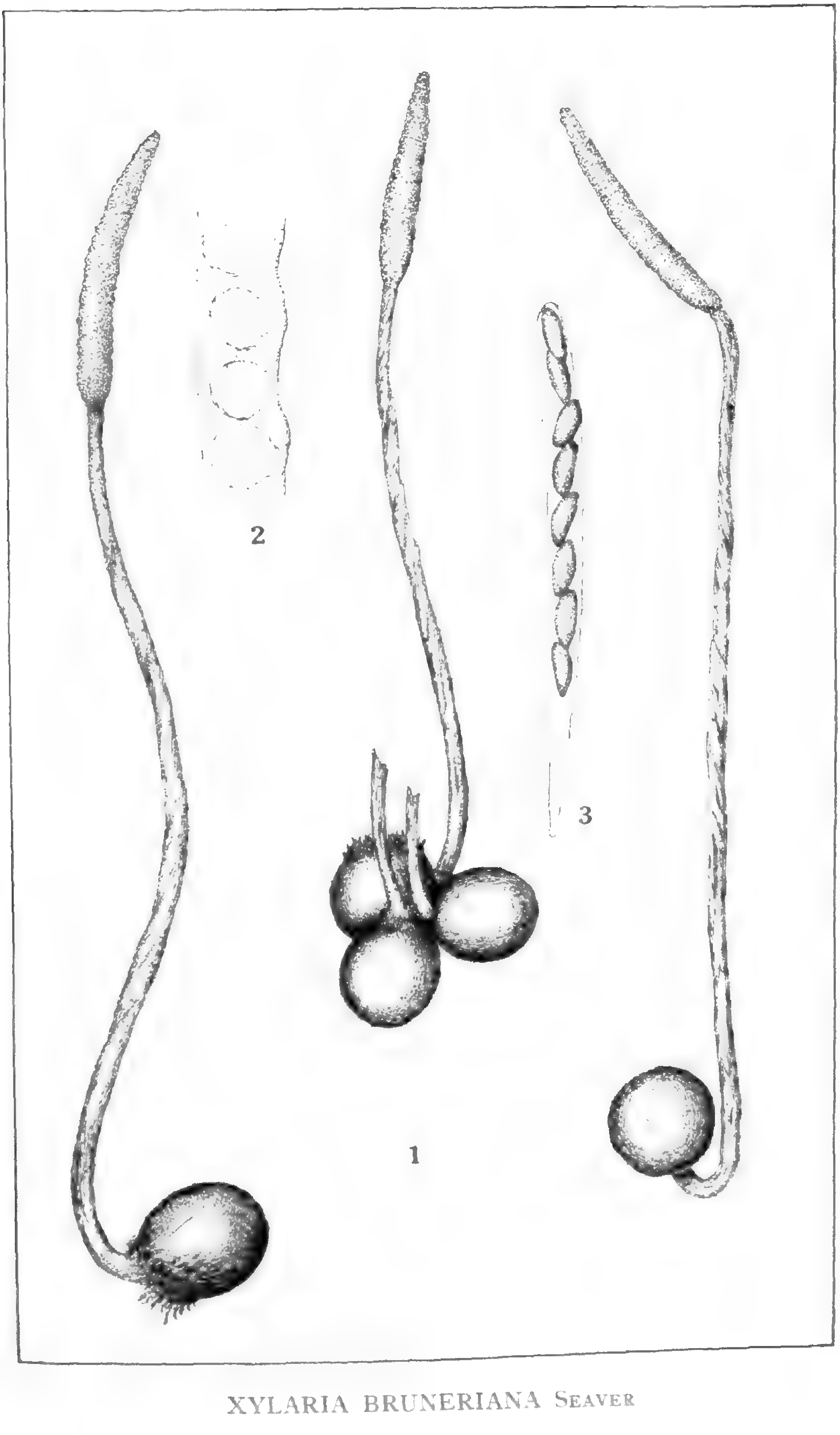
* Grevillea **15**: 89. 1887.

Description of plate 18

XYLARIA BRUNERIANA Seaver

FIG. 1. Several plants about natural size.
FIG. 2. Diagram of a section of the fertile head.
FIG. 3. Ascus with spores, drawn with the aid of the camera lucida.



XYLARIA BRUNERIANA Seaver

INDEX TO AMERICAN BOTANICAL LITERATURE

1920-1922

The aim of this Index is to include all current botanical literature written by Americans, published in America, or based upon American material; the word America being used in the broadest sense.

Reviews, and papers that relate exclusively to forestry, agriculture, horticulture, manufactured products of vegetable origin, or laboratory methods are not included, and no attempt is made to index the literature of bacteriology. An occasional exception is made in favor of some paper appearing in an American periodical which is devoted wholly to botany. Reprints are not mentioned unless they differ from the original in some important particular. If users of the Index will call the attention of the editor to errors or omissions, their kindness will be appreciated.

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Leighty, C. E., & Martin, J. H. The soft red winter wheats. U. S. Dept. Agr. Farm. Bull. 1305: 1–54. *f. 1–48.* D 1922.

Lindau, G. Acanthaceae austro-americanae. Notizbl. Bot. Gart. u. Mus. Berlin-Dahlem **8:** 245–247. 1 Jl 1922.

New species in *Aphelandra* (1), *Duvernoia* (1), *Jacobinia* (1), and *Beloperone* (2).

Lloyd, C. G. Mycological notes. Pp. 1105–1136. *pl. 186–201.* Cincinnati, Ohio. F 1922.

Lloyd, C. G. Mycological notes. Pp. 1137–1168. *pl. 202–217.* Cincinnati, Ohio. Jl 1922.

Mann, A. Suggestions for collecting and preparing diatoms. Proc. U. S. Nat. Mus. No. 2410: 1–8. 1922.

Mann, W. M. Notes on a collection of West African myrmecophiles. Bull. Am. Mus. Nat. Hist. **45:** 623–630. *f. 101–103.* 23 O 1922.

Taken from Wheeler; Ants of the American Congo Expedition. A contribution to the Myrmecophiles of Africa.

Markgraf, F. Eine neue Oleacee aus Peru. Notizbl. Bot. Gart. u. Mus. Berlin-Dahlem **8:** 219, 220. 1 Jl 1922.

Menodora pulchella, sp. nov.

Martin, T. L. Effect of green manure at different stages upon the relative abundance of *Actinomyces*, non-spore formers and spore-formers in the soil. Trans. Utah Acad. Sci. **2:** 245, 246. 1921.

Matthews, A. L. Some uncommon plant pests. Trans. Utah Acad. Sci. **2:** 41–44. 1921.

Includes discussion of "blackleg," caused by *Bacillus phytophthorus.*

Merrill, M. C. Distilled water as a medium for growing plants. Trans. Utah Acad. Sci. **2:** 75–83. 1921.

Merrill, M. C., & Abell, T. H. The breeding of canning tomatoes. Trans. Utah Acad. Sci. **2:** 133–138. 1921.

Miyake, K., & Imai, Y. On the inheritance of flower-colour and other characters in *Digitalis purpurea.* Jour. Coll. Agric. Tokyo **6:** 391–401. *pl. 43.* 20 N 1920.

Molisch, H. Oeschenbild und Pflanzenverwandschaft. Sitzungsber. Akad. Wissensch. Wien, Abt. 1. **129:** 261–294. *pl. 1, 2.* 1920.

Needham, J. G. A biological reconnaisance of Lake George [New York]. In Needham, J. G., *et al.*: A biological survey of Lake George, N. Y. 8–36. *f. 1–23.* 1922.

Nishimura, M. Studies in *Plasmopara Halstedii.* Jour. Coll. Agr. Hokkaido Imp. Univ. [Japan] **11:** 185–210. *pl. 1–6.* D 1922.

Oakley, R. A., & Westover, H. L. How to grow alfalfa. U. S. Dept. Agr. Farm. Bull. 1283: 1–36. *f. 1–10.* D 1922.

Pax, F. *Abatia.* In Herzog, T., Die von Dr. Th. Herzog auf seiner zweiten Reise durch Bolivien in den Jahren 1910 und 1911 gesammelten Pflanzen,—VI. Meded. Rijk's Herb. Leiden **46:** 10. 1922.

Pilger, R. *Alchemilla.* In Herzog, T., Die von Dr. Th. Herzog auf seiner zweiten Reise durch Bolivien in den Jahren 1910 und 1911 gesammelten Pflanzen,—VI. Meded. Rijk's Herb. Leiden **46:** 2. 1922.

Pilger, R. *Sageretia.* In Herzog, T., Die von Dr. Th. Herzog auf seiner zweiten Reise durch Bolivien in den Jahren 1910 und 1911 gesammelten Pflanzen,—VI. Meded. Rijk's Herb. Leiden **46:** 9. 1922.

Reiling, H. Beiträge zur Kenntnis der Kartoffelblüte und -frucht. Arbeit. Biol. Reichanstalt Land- und Forstwirtschaft **10:** 359–394. *f. 1–6.* 1920.

Solanum tuberosum.

Reynier, A. Le *Chenopodium ambrosioides* Auctorum, polycarpien, étudié en son double stade de développement. Bull. Soc. Bot. France **69:** 293–299, 378–385. 1922.

Rigg, G. B. Birch succession in sphagnum bogs. Jour. For. **20:** 848–850. D 1922.

Rigg, G. B. The sphagnum bogs of Mazama Dome [Washington]. Ecology **3:** 321–324. *f. 1.* D 1922.

Rodriguez, L. Contribucion à l'étude de la flore de Guatamala. Bull. Soc. Bot. France **69:** 373–378. 1922.

Rosen, H. R. The bacterial pathogen of corn stalk rot. Phytopathology **12:** 497–499. O 1922.

Pseudomonas dissolvens, sp. nov.

Sax, K. Sterility in wheat hybrids. II, III. Genetics **7:** 513–552. *pl. 1–3.* N 1922; 553–558. N 1922.

Schwerin, F., Graf von. Dendrologische Notizen XIII 6. Mitteil. Deutsch. Dendr. Ges. **1922:** 215–217. 1922.

Includes notes on *Prunus serotina.*

Schwerin, F., Graf von. Die Douglasfichte [*Pseudotsuga Douglasii*]. Mitteil. Deutsch. Dendr. Ges. **1922:** 53–67. 1922.

Shreve, F. Conditions indirectly affecting vertical distribution on desert mountains. Ecology **3:** 269–274. *f. 1, 2.* (O 1922).

Stevens, F. L. The *Helminthosporium* foot-rot of wheat, with observations on the morphology of *Helminthosporium* and the occurrence of saltation in the genus. Bull. Illinois Nat. Hist. Surv. **14:** 77–185. *pl. 7–34* + *f. 1–23* + *f. A–Y.* Je 1922.

Stoppel, R., & Trumpf. C. Beitrag zum Problem der Schlafbewegungen von *Phaseolus multiflorus*. Mitteil. Instit. Allgem. Bot. Hamburg **5:** 1–16. 1922.

T'Serclaes, J. de. Le noyau et la division nucleaire dans le *Cladophora glomerata*. Cellule **32:** 311–330. *pl. 1.* 1922.

Ulbrich, E. Ranunculaceae novae vel criticae V. Die grossblütigen Ranunculinae der Hochanden Südamerikas, *Rhopalopodium* Ulbrich n. gen., *Aspidophyllum* n. gen. und *Laccopetalum* Ulbr. Notizbl. Bot. Gart. u. Mus. Berlin-Dahlem **8:** 251–272. 1 Jl 1922.

Includes new species in *Rhopalopodium* (1) and *Aspidophyllum* (1).

Uphof, G. C. Die *Populus*–Arten im Südwesten der Vereinigten Staaten von Nordamerika. Mitteil. Deutsch. Dendr. Ges. **1922:** 172–175. 1922. [Illust.]

Weatherwax, P. A rare carbohydrate in waxy maize. Genetics **7:** 568–572. N 1922.

Weberbauer, A. Estudios concernientes a las relaciones entre la estructura anatomica de las hojas y la altura sobre el nivel del mar. Arch. Asoc. Peruana Prog. Ci. **2:** 50–67. 1922.

Wegelin, H. Blühende Früchte. Mitteil. Thurgauischen Naturf. Gesells. **24:** 161–170. *f. 1–8.* 1922.

Treats of Cactaceae.

Werdermann, E. *Taphrina Reichei* n. sp., ein neuer mexikanischer Hexenbesen. Notizbl. Bot. Gart. u. Mus. Berlin-Dahlem **8:** 221, 222. 1 Jl 1922.

Wernham, H. F., & Moore, S. Rubiaceae In Herzog, T., Die von Dr. Th. Herzog auf seiner zweiten Reise durch Bolivien in den Jahren 1910 und 1911 gesammelten Pflanzen, —VI. Meded. Rijk's Herb. Leiden **46:** 21–28. 1922.

Includes *Wernhamia*, gen. nov. and new species in *Psychotria* (1), *Borreria* (3).

Wester, P. J. Adlay—a new grain plant from the orient. Jour. Hered. **13:** 221–227. *f. 8–13.* 12 D 1922.

Coix lachryma-jobi L.

Wester, P. J. The breadfruit. Jour. Hered. **13:** 129–135. *f. 18–20.* 30 S 1922.

Wheeler, L. A. *Botrychium obliquum*, var. *dissectum* in Vermont. Am. Fern Jour. **12:** 127, 128. 30 D 1922.

White, C. T. An Australian *Citrus* relative. Jour. Hered. **13:** 119–121. *f. 15.* 30 S 1922.

Wickenheiser, H. C. Notes on a growth of young white birch. Torreya **22:** 84–86. O 1922.

Wiegand, K. M. *Carex laxiflora* and its relatives. Rhodora **24:** 189–201. 6 O 1922.

Includes 2 new species.

Willaman, J. J., & Davison, F. R. Biochemistry of plant diseases. IV. Proximate analysis of plums rotted by *Sclerotinia cinerea.* Bot. Gaz. **74:** 104–109 *f. 1, 2.* 15 S 1922.

Williams, C. F. The stems of grape hybrids. Jour. Elisha Mitchell Soc. **38:** 11, 12. S 1922.

Willis, J. C. Age and area. Pp. 1–259. Cambridge, England, 1922.

"A study in geographical distribution and origin of species."

Wilson, P. *Amorphophallus bulbifer.* Addisonia **7:** 33. *pl. 241.* 4 D 1922.

Wilson, P. *Anthurium scandens.* Addisonia **7:** 23, 24. *pl. 236.* 25 S 1922.

Wolf, F. A. The fruiting stage of the tuckahoe, *Pachyma Cocos.* Jour. Elisha Mitchell Soc. **38:** 127–137. *pl. 34–37.* S 1922.

Wolf, F. A. Studies on fermentation of rare sugars by plant pathogenic bacteria. Jour. Elisha Mitchell Soc. **38:** 12, 13. S 1922.

Wolf, W. Notes on Alabama plants. A new monotropoid plant. Am. Midl. Nat. **8:** 104–127. *pl. 1–3.* S 1922.

Cryptophila pudica, gen. and sp. nov.

Woodworth, C. M. Inheritance of cotyledon, seed-coat, hilum and pubescence colors in soy beans. Genetics **6:** 487–553. *f. 1–5.* N 1922.

Worseck, E. Sero-diagnostische Untersuchungen über die Verwandtschaftsverhältnisse der Monocotyledonen. Bot. Archiv **2:** 177–206. 15 O 1922.

Wrangel, —. Anbau von *Populus canadensis*, Kernfäule bei *Populus tremula*. Mitteil. Deutsch. Dendr. Ges. **1922:** 222, 223. 1922.

Wylie, R. B. The major vegetation of Lake Okoboji [Iowa]. Proc. Iowa Acad. Sci. **27:** 91–97. *f. 12.* 1920.

Yocum, L. E. Some phases of structure and development of garden pea and white sweet clover seeds as related to hardness. Jour. Elisha Mitchell Soc. **38:** 76–83. *pl. 5, 6.* S 1922.

Young, H. C., & Bennett, C. W. Growth of some parasitic fungi in synthetic culture media. Am. Jour. Bot. **9:** 459–469. *f. 1–4.* 20 O 1922.

Youngken, H. W., & LaWall, C. H. Anatomical and chemical studies of the sand spur (*Cenchrus tribuloides* L.) Am. Jour. Pharm. **94:** 567–583. *f. 1–14.* S 1922.

Zimmermann, W. Eigenartige Blüten-verhältnisse bei *Alnus* und Beobachtungen an *Betula, Corylus* und *Carpinus*. Mitteil. Deutsch. Dendr. Ges. **1922:** 112–134. *pl. 1, 2.* 1922.

Vol. 50 No. 10

BULLETIN

OF THE

TORREY BOTANICAL CLUB

OCTOBER, 1923

Resting spores of Empusa Muscae

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(WITH PLATE 19)

Introduction

The parasitic fungus, *Empusa Muscae*, like its host *Musca domestica*, has been found in most parts of the world—Europe, Africa, North and South America. Great numbers of flies are killed every fall in Europe and this country by this fungus. The possibility that such a natural parasite of the house fly as *Empusa Muscae* might be useful in combating its host has always made the study of this fungus attractive.

One of the problems which has attracted the most attention relates to the method of wintering of the parasite. Most of its congeners among the Entomophthoreae winter as some form of resting spore in the dead body of the host. So far the only report of such spores in *E. Muscae* was made by Winter in 1881. Brefeld, whose studies of the fungus and its relations to the fly are by far the most complete, concludes that *E. Muscae* does not form resting spores, disregarding Winter's observations as inconclusive.

Cohn, in 1885, was the first to study this disease of house flies in detail. He observed that flies dying of the disease attached themselves by their proboscides to window panes or other objects and here died of convulsions ("unter schweren Kämpfen"). The legs after death are spread out as in life and not curled under the body as is the case when death occurs naturally. The abdomen is swollen and often reflexed. He observed, too, that soon after death whitish rings of fungous

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[The BULLETIN for September (**50**: 283–316. *pl. 15–18*) was issued October 23, 1923.]

material appeared between the dark segments of the abdomen and that this condition was soon followed by a discharge of conidia.

Cohn gave the name *Empusa* to the fungus and described it as a three-celled organism. On tearing the tissues apart, he found the swollen hyphal cell, which he called the root-cell, within the body; arising from this he observed the long tube- or stalk-cell—the conidiophore or second cell; the latter gave rise to a third cell or conidium. He was not able to find within the fly's body any mycelial growth like that characteristic of other fungi.

In 1870, Brefeld described a series of observations on the infection of the fly by the conidia of the fungus, on the germination of the conidia, and on the growth and development of the fungus within the host's body. Brefeld found that the conidia germinated upon the fly's body, and that the germ tubes were able to pierce the thin integument of the under side of the body directly. Here the germ tubes give rise to large cells. These large cells, feeding upon the fat-cells and body-juices of the fly, give rise by budding to other large cells. From these cells the conidiophores finally grow out, so that the insect's body appears to be completely filled with these hyphal tubes. In five or six days after infection the insect dies, after attaching itself by its proboscis to a surface. Each hyphal tube ends with the building of a conidium. The throwing off of spores lasts two days. The rest of the conidiophore, after the discharge of the conidium, disintegrates in the fly's body.

Thaxter's description of the vegetative development of the genus *Empusa* seems to accord with that given by Brefeld for *E. Muscae*. According to Thaxter, the germ tube of a conidium enters the host's body and there grows rapidly in the body-juices of the insect. It does not produce a mycelium, however. Short, thick cells are formed, which reproduce rapidly by budding and, finally, completely fill the host's body. Thaxter has given the name "hyphal bodies" to these short, thick cells.

The house fly disease, as has been commonly observed in this country and Europe, seems to become most evident and widespread in the fall of the year. The flies appear in early spring, become more and more plentiful during the summer and fall, and again disappear during the cold months. Statistical data to confirm this view are so far lacking, but it seems to be a matter of common observation. No one records finding the fungus before July in this country.

Brefeld found that the conidia of *E. Muscae* were very short-lived, not living more than a few days. Not being able, during all his observations, to find any resting spores, sexual or asexual, he was puzzled as to how the fungus could live through the winter when there were no flies to pass on the infection. He came to the conclusion that the disease must be endemic in the South, where the flies are active throughout the winter, and that as summer comes on the disease travels northward. Brefeld concludes, on the ground of his own and Dr. Möller's failure to observe any form of resting spore either in Europe, Africa, or South America, that *Empusa Muscae* has lost the power to produce resting spores.

Olive succeeded in keeping the fungus, *E. Sciarae*, on a small fly, *Sciara* sp., under observation for a whole year, and in all that time did not observe the formation of resting spores at all. He notes that the spontaneous appearance of the fungus in the laboratory cultures of the fly as early as March renders Brefeld's hypothesis improbable for this case. Olive concludes that *E. Sciarae* probably lives upon the successive generations of the flies breeding in the dung of warm stables through the winter. The ability of *Empusa Sciarae* to grow and reproduce asexually, attacking one generation of flies after another without the intervention of a sexual stage or resting period, is evident from Olive's cultures maintained throughout the year.

Thaxter finds that Brefeld's idea of the fungus moving northward each year with flies from the South is refuted by his observations that the disease appears in the South in July and that it regularly makes its appearance in the North at the same date.

Lebert, in 1857, in his paper on the fungous disease of flies, shows several figures which Thaxter refers to as possible resting spores. These figures do not seem to me to be at all likely to be representations of the resting spores of *E. Muscae*.

Giard, in 1878, stated that the reason resting spores of *E. Muscae* had not been found was that they are not formed in flies that have died indoors and that they do not occur in the interior of the fly's body. He found irregularly rounded, thick-walled cells on the outside of the fly's body, which he believed to be the resting spores of the fungus. Each spore contained a large globule of oil in its centre, and was surrounded by a layer of protoplasm. He added that these were seen by Brefeld, who considered them to be identical with conidia.

I have found such irregular cells on the exterior of the fly's body and believe them to be plasmolyzed or dried conidial cells or perhaps portions of the conidiophores which have become dried up or shrunken and appear thick-walled. I have found such cells, not only in the external mass of shrunken conidiophores of dried house flies which contain perfectly formed and rounded resting spores, but also in the external mass of conidiophores of very dry blue bottle flies attacked by *Entomophthora X* (Riddle), whose abdominal cavities contain fully developed, rounded resting spores with the characteristic bullate processes on their outer walls.

It is worth while to review Winter's observations more carefully. He reported that he found dead flies attached to a window, most of which showed only the conidial stage, and he identified these conidia as belonging to *E. Muscae*. Three of these flies contained a mycelium in their body cavities. From the hyphae rounded bodies arose either as lateral or terminal swellings. These rounded bodies upon maturing were colorless, rich in oil drops, and covered with a uniformly thick membrane. They measured 30–50 μ in diameter. Brefeld's only reference to Winter's observations is in a footnote; this states that Winter found resting spores in several flies and believed them to be the spores of *E. Muscae*.

It does not seem altogether improbable that Winter may have seen the resting spores of *E. Muscae*. However, since no cytological study of the fungus was made and since no drawings were given, his statements have remained under question.

Lakon, in his paper on the wintering of *E. Muscae*, concludes that, since Winter found the resting spores once, resting spores must exist in this fungus, although no one since Winter has been able to find them. He adds that it is well known that the disease can occur upon other related flies. He suggests the importance of searching for the resting spores on other species of flies which are supposed hosts of *E. Muscae*.

OBSERVATIONS

In September, 1921, I began a study of *Empusa Muscae* and had under observation great numbers of flies, many of which were attacked by the fungus and died of the disease. I fixed and embedded for cytological study both fresh material and some very old dry specimens of flies. These dried house flies were found sticking to walls and windows by means of their proboscides. The live flies, which I had under observation and which died of the disease, came from the same locality near Ridgewood, New Jersey.

The dried flies were put in Merkel's solution for two hours, followed by a diluted solution of Flemming's weak for twenty-four hours. The material was run up into paraffin in the usual way, and the sections were cut 5 μ thick and stained with Flemming's triple stain. The sections of two of these flies showed multinucleated, rounded, thick-walled spores in their abdomens.

Having found resting spores in these dried house flies, I immediately began to search about for other dried specimens. Several dried flies were found sticking by means of their proboscides to the white porcelain glass shades around the electric lights in the laboratory. Evidently in making transfers of the flies under observation from one glass chamber to another, diseased flies had escaped into the room, and had attached themselves to the glass shades. These dried flies showed further evidence of having died of the disease, since, between the segments of the abdomen, the thin membrane still projected as if it had been pushed out by the pressure of the conidiophores, and the segments of the abdomen were still somewhat apart. Upon sectioning and staining this material, the same form of resting spores was found again, although the material was not as good as the first.

In January, I secured a number of dried flies from house walls in the same locality, and resting spores were also found in this material. In dry specimens of flies secured about dwellings in New York City this year (1922) I have again found resting spores, some fully formed, and others in process of formation.

Frequently such old dry specimens show only traces of disintegrated, mycelial threads and are often filled with bacteria of various sorts. Apparently resting spores are not always formed, but their occurrence in different lots of material, collected in the fall and winter of 1921 and 1922, shows that they are by no means rare.

The chief reason why investigators have commonly failed to find the resting spores is apparently their failure to examine old, dried up material, such as can be found attached to walls and windows throughout the winter. The resting spores are evidently most commonly, though not always, formed very late and as a final stage of the disease, after the body of the fly has begun to dry up.

The evidence is clear that the resting spores I find belong to *Empusa Muscae* and not to *Entomophthora americana* or any of the other entomophthorous forms that are said to occur in the house fly. All the flies studied, fixed, and sectioned are typical house flies. The flies sectioned show no traces of other fungi.

That the fungus is *Empusa Muscae* is definitely established by the fact that the conidia in all my sections which show them fully formed or in process of formation are the broad, multinucleated type characteristic of this species (FIG. 1). They do not resemble in the least the narrower and uninucleated conidia of *Entomophthora americana*. In none of my sections have I observed a single branching conidiophore. The conidiophores of *E. americana* are regularly branched. Many of the sections containing resting spores also show the multinucleated conidia and simple conidiophores of *E. Muscae* projecting between the abdominal segments.

Finally the insects were all found attached by means of their proboscides and not by means of rhizoids appearing at other regions of the body, as is the case with the other entomophthorous forms that are said to occur upon the house fly.

As described in the literature several forms of resting spores occur in the Entomophthoreae and they may be either sexual or asexual in origin. When they are of sexual origin, they are described as arising through the fusion of equal gametes or equal hyphal bodies. The terms encysted hyphal body, chlamydospore, and azygospore are used to designate resting spores of asexual origin.

The term chlamydospore is properly used to designate a resting spore formed by the rounding up of portions of the protoplasm of a hyphal tube. This rounded mass of protoplasm becomes thick-walled and forms a resting spore.

The term chlamydospore might be applied in the case of the Entomophthoreae to resting spores originating in any one of at least four different ways:

1. The rounding up of the protoplasm in a hyphal body to form a rounded, thick-walled spore within the hyphal body.
2. The swelling up of the tip of a hyphal filament to form a terminal, thick-walled resting spore.
3. The formation of rounded, thick-walled spores at different points along the hyphal filaments.
4. The formation of rounded, thick-walled spores as buds arising either from a hyphal body or a hyphal filament.

A clearer and more definite use of terms is much needed for these various cases.

When the hyphal body itself becomes thick-walled forming an irregular thick-walled body the term "encysted hyphal body" alone should be employed.

The term azygospore has been used in the Entomophthoreae not alone to designate a resting spore arising without a preliminary fusion of cells. It has been used also for spores borne at the tips of hyphae, formed along the hyphal threads, or arising as buds from hyphal bodies or filaments. Resting spores arising in all these ways, it seems to me, are merely asexual spores of typical chlamydospore type.

In my opinion the term azygospore should be restricted to thick-walled resting spores arising from either of two sexual gametes which have failed to fuse. Such has been the use of the term in the mucors, where in many cases two gametes approach each other, but do not fuse. Each or only one of the gametes then forms a thick wall and becomes an azygospore.

The resting spores of *Empusa Muscae* are relatively large, thick-walled bodies. They are generally well rounded, and are multinucleated. They are approximately 30 μ in diameter. Oval spores generally measure 21 × 30 μ.

I have no evidence to show that a pairing or fusion of nuclei takes place within these resting spores, although in many spores the nuclei do appear to be arranged in pairs. There is no evidence of either a reduction or an increase in the number of nuclei contained within a young spore as compared with a more mature spore, such as Vuillemin describes for *Entomophthora gleospora*. The younger, thin-walled spores contain about the same number of nuclei as the very thick-walled spores.

Oil globules are present in the older spores. These usually occur as a few large drops. There may be a single large oil drop present, so that the protoplasm appears to be pushed to one side of the spore, and the nuclei are then grouped closely together in the denser mass of protoplasm. Generally the nuclei are scattered rather irregularly through the protoplasm. In the young spores, the protoplasm is more or less homogeneous and fine granular threads connect the nuclei (FIGS. 6 and 7).

The resting spores show an outer thin wall or membrane around them, which is probably the old hyphal wall. Inside this is the thickened wall. This wall is of an even thickness around the entire spore and is quite smooth even in mature spores. The wall appears to be composed of a single layer, and probably grows in thickness by deposition of material from the outer region of the protoplasm. Within the thick wall is the rounded protoplasmic mass, which may be only very slightly withdrawn from the thick wall, or very much so, the latter condition being due probably to poor fixation (FIG. 5).

The resting spores are obviously asexual in origin. They are chlamydospores in the strict sense. They arise most commonly at the tips of short hyphae or hyphal fragments (FIGS. 3 and 4) or by the division and rounding up of the protoplasm in the hyphal filaments themselves (FIG. 7). In both fresh and stained material, I have recently found some evidence that they may arise as buds on hyphal fragments or hyphal bodies (FIGS. 2 and 9).

The hyphal cells, at the end of the nutritive period of the fungus, give rise to long hyphal tubes which grow out toward the body walls of the host. These hyphal tubes are non-septate and contain many nuclei. They are always unbranched. Many reach the body wall of the insect, and travel along parallel to it, until the thin membrane between two segments of the abdomen is reached. Here, with other tubes that have reached this region directly, they push out the membrane and finally grow out to the exterior. At the tip of each conidiophore, a conidium arises as a bud and, when mature, is finally cut off by an ingrowing wall. The conidium is forcibly abjected by the bursting of the upper swollen region of the conidiophore.

The remainder of the conidiophore tube, as Brefeld also observed, disintegrates. The collapsed, shrunken, and disintegrating hyphal tubes can be seen filling the openings between the segments of the abdomen and projecting a little from the body in sections of flies in which the conidiophores have already discharged their conidia. Great numbers of bacteria are always present feeding upon the contents of the disrupted hyphae.

After the discharge of conidia, there still remain within the abdominal cavity numerous hyphal filaments and other hyphal fragments which have not been able to reach the exterior. As long as suitable moist conditions are present, these hyphal tubes remain alive and unaltered and are later able to force their way between the collapsed conidiophores to the exterior to form and discharge their conidia. If, however, the weather is dry, the development of conidia may be checked, and it is probably under these conditions that the resting spores are formed.

The terminally formed resting spores arise as swellings in the terminal regions of hyphal tubes and are finally cut off by cross walls (FIG. 4). Within the hyphal membrane the heavy wall is formed and a somewhat pyriform or more or less oval resting spore results. Those resting spores which are formed along the hyphal tubes are generally more rounded in form. I have found two, three or four round, thick-walled spores occurring in a chain, connected by the collapsed and emptied hyphal tube membrane in which they arose (FIGS. 5 and 7). Not all the resting spores are round or oval. Some are simply portions of the hyphal tube which have become only slightly more swollen than the original width of the hyphal tube.

Resting spores are found only in the abdominal cavity, although traces of vegetative mycelial threads can be seen in the thorax and head of the insect. The germ tube first makes its entrance into the abdominal cavity as Brefeld found, and the fungus passes most of its vegetative state feeding upon the body juices and soft tissues which are found in this region.

SUMMARY

Resting spores are formed in the life cycle of *Empusa Muscae.* Failure to find them on the part of Brefeld and other students is apparently because they are formed very late in the development of the fungus.

These resting spores are in my opinion to be regarded as chlamydospores, formed under dry conditions after conidial discharge is no longer possible. They are formed most frequently as terminal swellings on short hyphal fragments or tubes, or intercalary in the hyphal filaments, or by apparent budding from hyphal bodies. They are generally rounded cells, with smooth, evenly-thickened walls, and contain many nuclei.

I wish to gratefully acknowledge my indebtedness to Professor R. A. Harper for his assistance and advice in this study and in the preparation of this paper.

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BIBLIOGRAPHY

Brefeld, O. Entwicklungsgeschichte der *Empusa Muscae* und *E. radicans.* Bot. Zeit. **28**: 161–166, 177–186. 1870.

———. Untersuchungen über die Entwickelung der *Empusa Muscae* und *Empusa radicans.* Abhandl. Naturf. Ges. Halle **12**: 1–50. *pl. 3, 4.* 1871.

———. Ueber die Entomophthoreen und ihre Verwandten. Bot. Zeit. **35**: 345–355, 368–372. 1877.

———. *Conidiobolus utriculosus* und *minor.* Unters. Gesammt. Mykol. **6**: 68–72. 1884.

———. Die Kultur der Pilze. Ibid. **14**: 118–125. 1884.

Cohn, F. A. *Empusa Muscae* und die Krankheit der Stubenfliegen. Nova Acta Acad. Caes. Leop. Carol. Germ. Nat. Cur. **25**: 301–360. *pl. 9–11.* 1855.

Giard, A. Deux espèces d'*Entomophthora* nouvelles pour la flore française et présence de la forme *Tarichium* sur une muscide. Bull. Sci. France et Belgique [Bull. Sci. Depart. du Nord II. 2] **11**: 353–363. 1879.

Lakon, G. Die Insektenfeinde aus der Familie der Entomophthoreen. Zeitschr. Angewandt. Entomol. **5**: 161–216. 1919.

———. Bemerkungen über die Überwinterung von *Empusa Muscae.* Ibid. **5**: 286–290. 1919.

Lebert, S. Ueber die Pilzkrankheit der Fliegen. Neue Denkschr. Allgem. Schweiz. Ges. **15**^{5}: 1–48. *pl. 1–3.* 1857.

Olive, E. W. Cytological studies of the Entomophthoreae. I. The morphology and development of *Empusa.* Bot. Gaz. **41:** 190–208. *pl. 14, 15.* 1906.

———. Cytological studies of the Entomophthoreae. II. Nuclear and cell division of *Empusa.* Ibid. **41:** 229–261. *pl. 16.* 1906.

Riddle, L. W. On the cytology of the Entomophthoraceae. Proc. Am. Acad. **42:** 175–197. *pl. 1–3.* 1906.

Thaxter, R. The Entomophthoreae of the United States. Mem. Boston Soc. Nat. Hist. **4:** 133–201. *pl. 14–21.* 1888.

Vuillemin, P. Développement des azygospores chez les Entomophthorées. Compt. Rend. Assoc. Franc. Avanc. Sci. Congres de Paris 670–685. *pl. 6.* 1900.

———. Développement des azygospores chez les Entomophthorées. Compt. Rend. Acad. Sci. Paris **130:** 522–524. 1900.

Winter, G. Zwei neue Entomophthoreen-Formen. Bot. Centralbl. **5:** 62–64. 1881.

Explanation of plate 19

The drawings were made with the aid of the Abbé camera lucida, from sections 5 µ thick and stained with Flemming's triple stain, except figure 8 which is a drawing from fresh material mounted in lacto-phenol.

A Zeiss microscope was used with a 1/12 inch oil immersion objective and a number 3 ocular. The magnification is about 1200 diameters. FIG. 8 was drawn with the Zeiss objective D and number 3 ocular.

FIG. 1. A broad multinucleated conidium characteristic of the species.

FIG. 2. A young resting spore which probably arose by budding from the tip of a hyphal fragment.

FIG. 3. A young resting spore formed at the tip of a hyphal tube.

FIG. 4. A young chlamydospore cut off from the tip of a conidiophore.

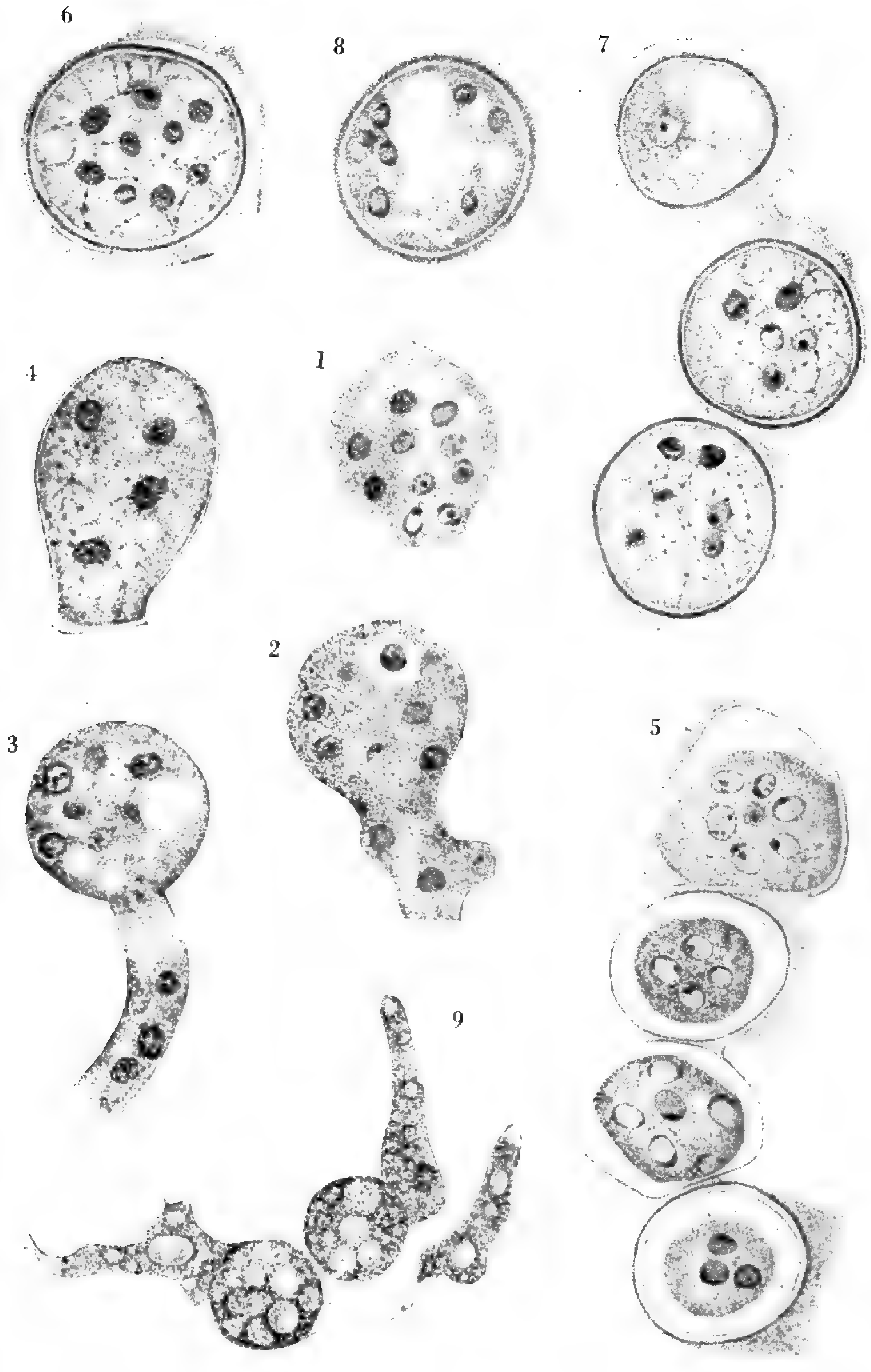
FIG. 5. A chain of four young spores. This material was not fixed well and shows considerable shrinkage. The protoplast in each spore is drawn away from the inner membrane, which is itself shrunken away from the spore wall. The outer thin membrane does not show and is probably closely applied to the slightly thickened spore wall. I am not certain that the uppermost and irregularly shaped spore belonged to the same hypha. This spore may have arisen from another hypha which lay across the first.

FIG. 6. A chlamydospore showing numerous nuclei and granular threads connecting them.

FIG. 7. A chain of three chlamydospores connected by the old conidiophore tube wall.

FIG. 8. A more mature resting spore.

FIG. 9. Two young rounded spores at the tips of hyphal filaments which, as in FIG. 2, probably arose by budding. The protoplasm contains many oil drops.



GOLDSTEIN: RESTING SPORES OF EMPUSA

An ecological study of Cheilanthes gracillima

F. L. PICKETT

(WITH THIRTY-THREE TEXT FIGURES)

Cheilanthes gracillima D. C. Eaton is found in the mountains of the Pacific Coast region from British Columbia to Mexico. It is usually found at altitudes of 5000–7000 feet, and more rarely as low as 1500 feet. J. H. Sandberg* reported finding this fern in Idaho on "mountains near Viola, Latah County, June 26 (1892)." Later surveys have located it over most of the range of Thatuna Hills, extending from Latah County in Idaho westward and northward into Whitman County, Washington. These "Hills" are old mountain peaks composed of granite and quartzite rocks with an altitude of 3000 to nearly 5500 feet. They stand out in the landscape as more or less isolated peaks or buttes, rising 1000–2500 feet above the great lava plateau of the Palouse Country, as the plains of southeastern Washington are called.

Throughout its range *C. gracillima* is an inhabitant of rocky, exposed ledges, and consequently has but a limited water supply. In the southern part of its range climatic conditions combine with habitat to reduce the amount of available water, so that this *Cheilanthes* has come to be known as a typical xerophytic species. The isolated buttes in Whitman County, Washington, are subject to a combination of severe conditions. The total rainfall of about twenty-four inches is limited almost wholly to the period between the first of October and the last of May. Throughout the summer almost constant winds with a very low humidity prevail. The temperature range through the year is from − 20° to + 110° F. Add to these conditions the fact that *C. gracillima* grows only in the crevices of otherwise bare rocks, with southern or southeastern exposure, with no other protection than an occasional dwarf specimen of *Pinus ponderosa*, and it is at once evident that some striking characteristics of structure and development must be present to make possible the vigorous growth of this fern in this locality. The fern is fairly common, however, and does show normal, vigorous plants.

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* See Holzinger, Contr. U. S. Nat. Herb. **3**: 267. 1895.

FIELD AND LABORATORY INVESTIGATION

Examination of *C. gracillima* at different seasons of the year shows the following items aside from the developmental history, which is given later. The most vigorous growth is in the spring, March to May. Fronds are persistent through the summer and to some extent into the second summer. With the advent of summer and the reduction of both atmospheric and soil moisture the fronds and individual pinnae are closely curled together. They take on a blue-gray appearance, and are harsh to the touch, like herbarium specimens. The rootstocks are buried under a few inches of light soil in the rock crevices but are quite dry in midsummer. The roots are small, fibrous, covered with a definite corky layer, and extend sometimes as far as four or five feet through the crevices in the rocks. An abundant growth of new roots is produced by the rootstocks each spring.

On August 10, 1921, mature, fertile fronds were collected for cultural work. Although mature, these fronds had lost but few, if any, of their spores when collected. They were placed in paper folders and stored in the laboratory. When the folders were opened on November 27, but very few loose spores were found, and examination showed the sporangia unopened, almost without exception. After being in water for an hour some fronds were placed on filter paper in a desiccator over night. When examined the next morning the paper was well covered with spores. By repeating this process three or four times it was possible to empty nearly all the sporangia.

On November 28, 1921, several cultures were started by sprinkling spores over dishes of Knop's solution, one-half usual strength, over dishes of agar agar made up with one-half strength Knop's solution, and over sterilized soil in perforated clay saucers. The spores germinated freely after ten to twelve days, and by December 17 germination had proceeded far enough for the cultures to show a distinct green surface. Differences of temperature through a fairly wide range, 45°–70° F., seemed to make no appreciable change in the rate or percentage of germination.

The spores of this plant are nearly spherical with their clearly marked sutures between pairs of thickened, rounded ridges FIG. 1). They show marked variability as to size, measuring

425–600 μ in greatest diameter. The exine is very hard and brittle. Slight crushing under a coverglass regularly results in such fractures as shown in FIGS. 2, 3 and 4, and the germination of well-matured spores results in the same type of irregular fracture. Spores which are immature, as shown by their light color and thinner exine, may produce normal plants, but the germination of such spores usually results in the separation of exine-segments along the sutures. The spores are uninjured by desiccating influences. Fronds placed in desiccators over anhydrous calcium chloride in November, 1921, remained there until March, 1923, and then furnished spores nearly all of which were capable of germination. A number of interesting questions enter at this point. It is not desirable to take them up in detail at this time; but for other investiagtors who may wish to know more of details it should be said that the desiccators used were

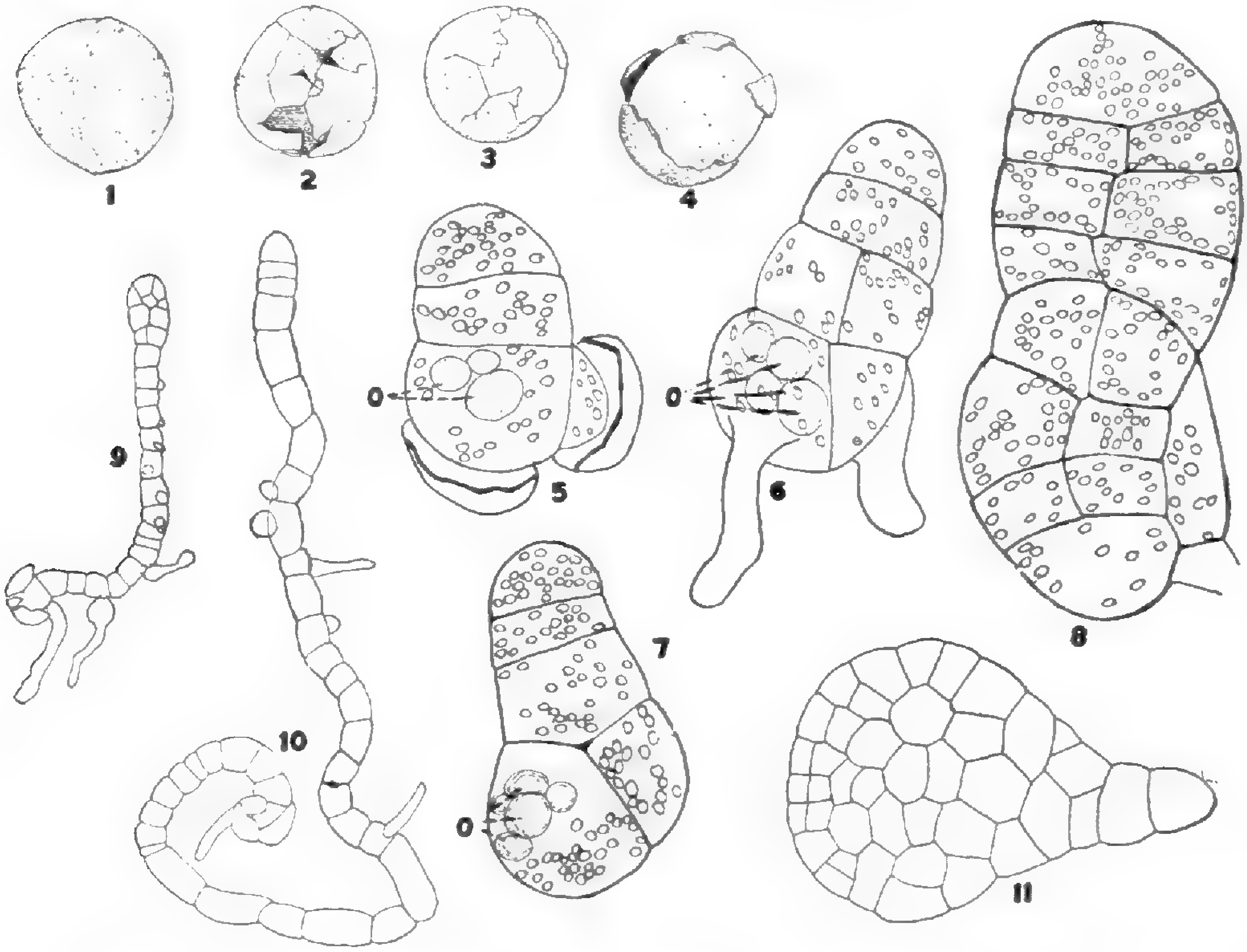
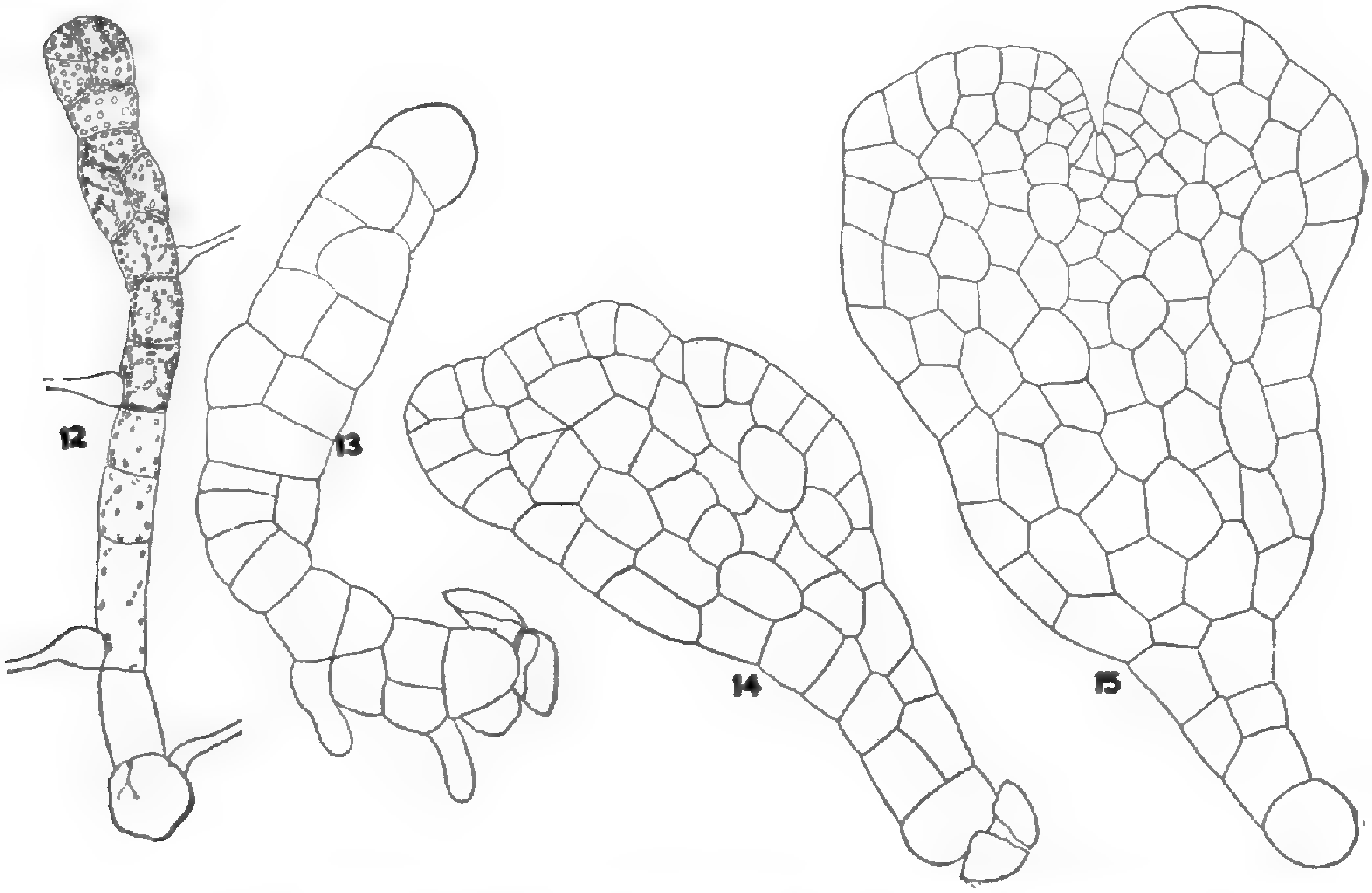


FIG. 1. A normal mature spore. FIGS. 2–4. Spores showing typical fracture of the exine under pressure. FIGS. 5–8. Young sporelings showing distribution of oil-globules, O, and chloroplasts. FIGS. 9, 10. Unusually filamentous forms of antheridial plants, the second having developed under water. FIG. 11. A normally developing archegonial plant showing unusual symmetry.

of standard, Scheibler type, non-tubulated, with well-ground joints sealed with a film of vaseline, having a total capacity of about 2 liters and containing 300 grams of freshly fused $CaCl_2$.

Microscopic examination of spores in sections made of pinnules taken from the desiccator, plunged directly into chloroform or benzole and then imbedded in paraffine, showed the cytoplasm dry and shrunken to the sides of the spore. In general external appearance the spores were the same after desiccation as before, the exine retaining its normal spherical form.



FIGS. 12, 13. Elongated forms produced in reduced light. FIGS. 14, 15. Normally developing archegonial plants.

The germination of the spores and the development of the prothallia show some unusual features. A protonemal chain of from two to ten cells is regularly formed before the oblique wall cutting off the first apical cell appears, as shown in many of the figures. Especially abundant in cultures exposed to bright light were plants almost or entirely lacking this protonemal development (FIGS. 5–8). The spores when first germinated show several drops of oil, and this is evident after several cells have been formed (FIGS. 5–7). Very quickly after germination the cells of the spore and succeeding cells show abundant chlorophyll (FIGS. 5–8). The prothallia are strictly dioecious and show marked differences in development. Archegonial plants are nearly symmetrical (FIGS. 11, 15), with a well-developed median thickening, and may reach an extreme length of 2 mm. Antheridial plants are much smaller, very irregular in form, without median thickening, usually less than 0.5 mm. in length and sometimes filamentous (FIGS. 9, 10), and may have less than twenty cells when the first antheridium appears. So small are the antheridial plants and so irregular in shape that they may be overlooked in a casual examination of a soil culture.

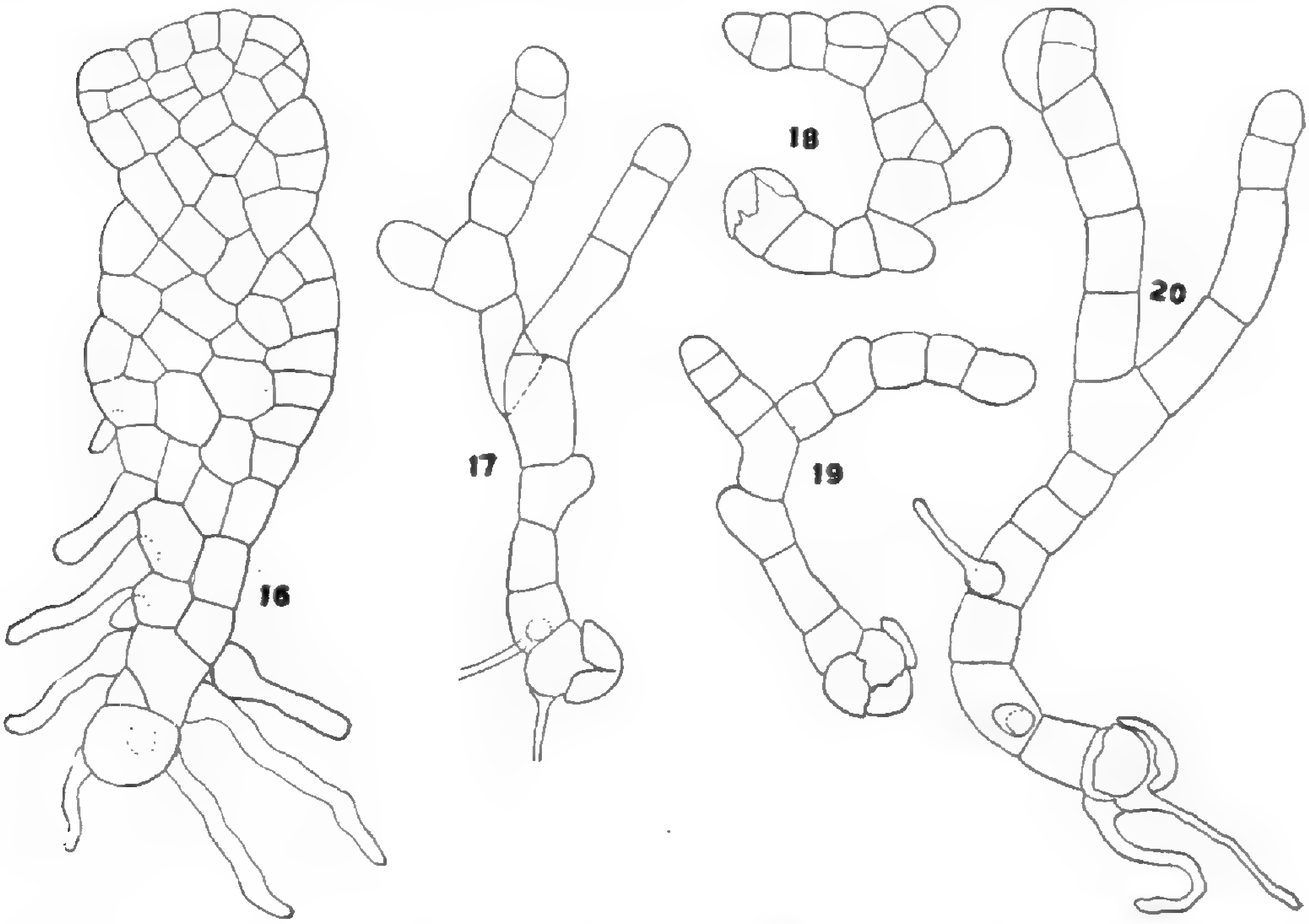


FIG. 16. Normal prothallium showing resumption of growth over wide apical area after period of drought. FIGS. 17–20. Sporelings showing tendency for proliferation through multiple growing points.

The author has elsewhere discussed at length the extreme sensitiveness to changing light intensity shown by other fern prothallia.* The young prothallia or sporelings of *C. gracillima* show much of the same sensitiveness. This is well shown by FIGS. 11, 12, 13, 14 and 16, in which FIGS. 11, 14 and 16 are of sporelings grown on Knop's solution in Petri dishes near the laboratory window, and FIGS. 12 and 13 those of plants from

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* Some ecological adaptations of certain fern prothallia—*Camptosorus rhizophyllus* Link., *Asplenium platyneuron* Oakes. Am. Jour. Bot. **1**: 477–498. *pl. 49, 50 + f. 1–19.* 1914.

similar cultures shaded by the first, which were immediately above them. Exchanging the positions of these dishes made sufficient change in light intensity to produce marked changes in the growth of the sporelings. Very nearly the same peculiarities of form appeared when plants were allowed to develop under water. FIGS. 10 and 25 represent extreme cases of irregular development under water. These, being antheridial plants, would be expected to show irregular growth, but they are much more attenuated than plants grown on the surface of culture fluid or on soil. FIG. 25 is that of a plant developed wholly under water in normal light.

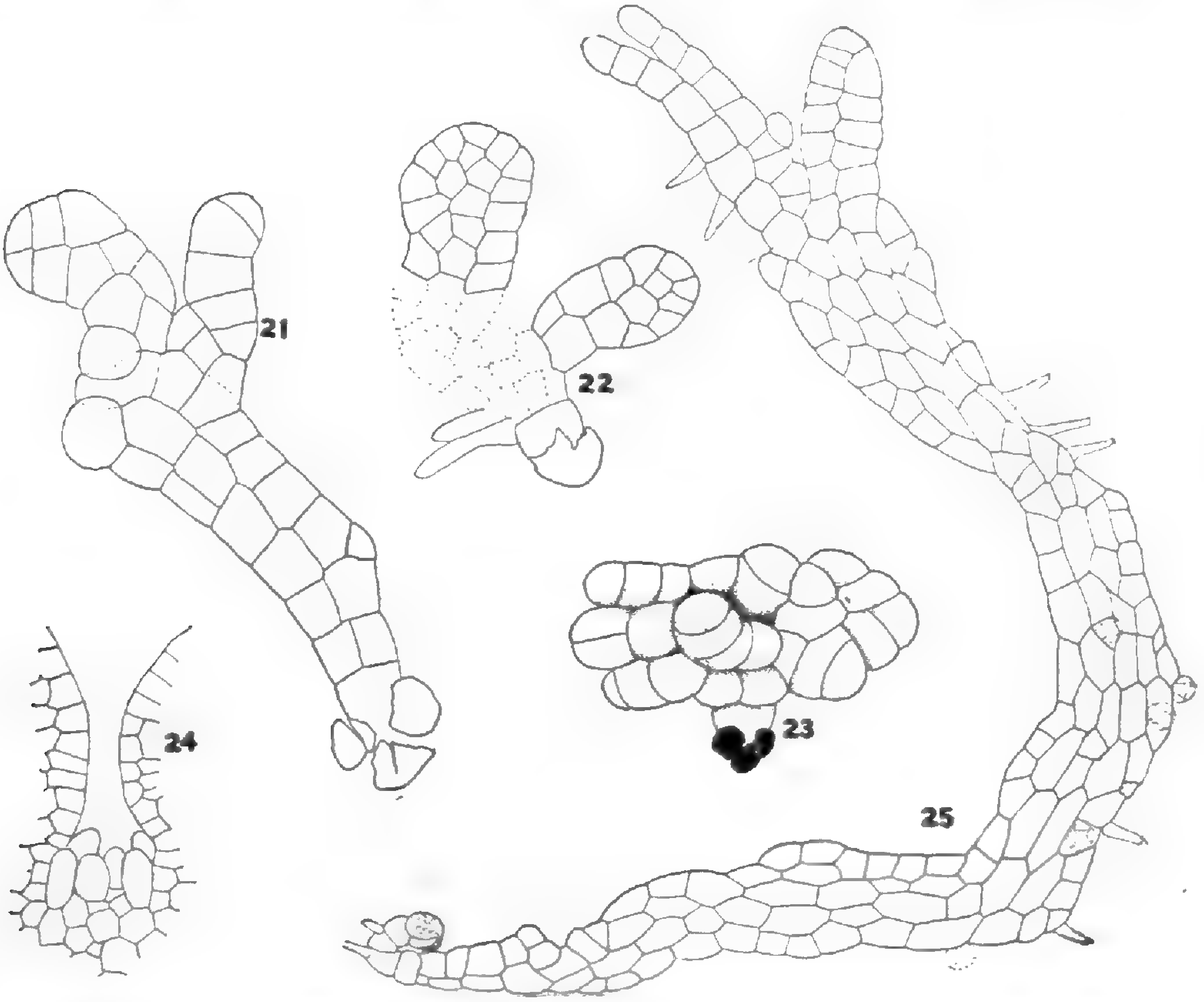


FIG. 21. Sporeling showing tendency for proliferation through multiple growing points. FIG. 22. Marginal proliferation following injury to young plant; dotted lines show injured cells. FIG. 23. Unusual production of growing tips in three or more planes. FIG. 24. Unusual growth of marginal cells in sinus. FIG. 25. Greatly elongated antheridial plant developed under water.

The soil cultures grew nicely up to April, 1922. At that time some cultures were flooded and within a month showed abundant sporophyte growth. Other cultures were allowed to become entirely dry after April 1, 1922. This condition continued up to July 31, 1922, when one of the cultures was moistened from below. The plants in this culture showed complete recovery the following day. This culture was not moistened again until November 6, when it again showed complete recovery. On September 21, a second culture which had received no water since April 1 was moistened from below and on the following day this culture showed complete recovery. From these experiments it was evident that the prothallia of this plant were able to withstand very unusual drought conditions. Steps were taken to determine more fully their ability to survive such treatment. On November 7, portions of soil bearing prothallia were taken from a culture, which had not been moistened since April 1, and placed in two desiccators, one containing anhydrous calcium chloride and the other anhydrous phosphoric acid (sticks). From time to time shall portions of these cultures were removed and were moistened by placing them upon moist filter paper. For a considerable time this was repeated in forty-eight hour periods until it became evident that the extreme desiccation was doing but little damage, after which the periods were lengthened. On January 29 the last portion of these cultures was removed. Its plants showed almost complete recovery within a few hours after being moistened. These prothallia had thus survived exposure to absolute drought for a period of thirteen weeks. We have no reason to believe any moisture could have reached them in any way during that time. The soil on which they were growing was a small cake, perhaps 10 sq. cm. in total extent in the beginning and at no place exceeding 5 mm. in thickness; moreover, this soil was taken from a culture which had been exposed to normal dry atmosphere through a period of seven months before being placed in the desiccator. The same type of apparatus was used as described above, and the same precautions observed to prevent entrance of invalidating factors.

Final proof of the survival of plants was made by placing them under normal conditions of growth for a considerable period. In every case where they have been reported as surviving the desiccation, they continued to grow and even produced sporophytes. In the case of plants which had already produced sporophytes before being placed in extreme conditions it was found that prothallia and sporophytes survived equally well.

As in the case of spores, so prothallia and young sporophytes show no evidence of ability to *resist* desiccation. Vigorous plants on moist soil when exposed to the warm, dry atmosphere of a class room were completely wilted in thirty to forty minutes. The peculiar characteristic of this, as of other ferns studied by the writer, seems to be the ability to survive the actual loss of water far below the percentage usually considered essential to the preservation of life.

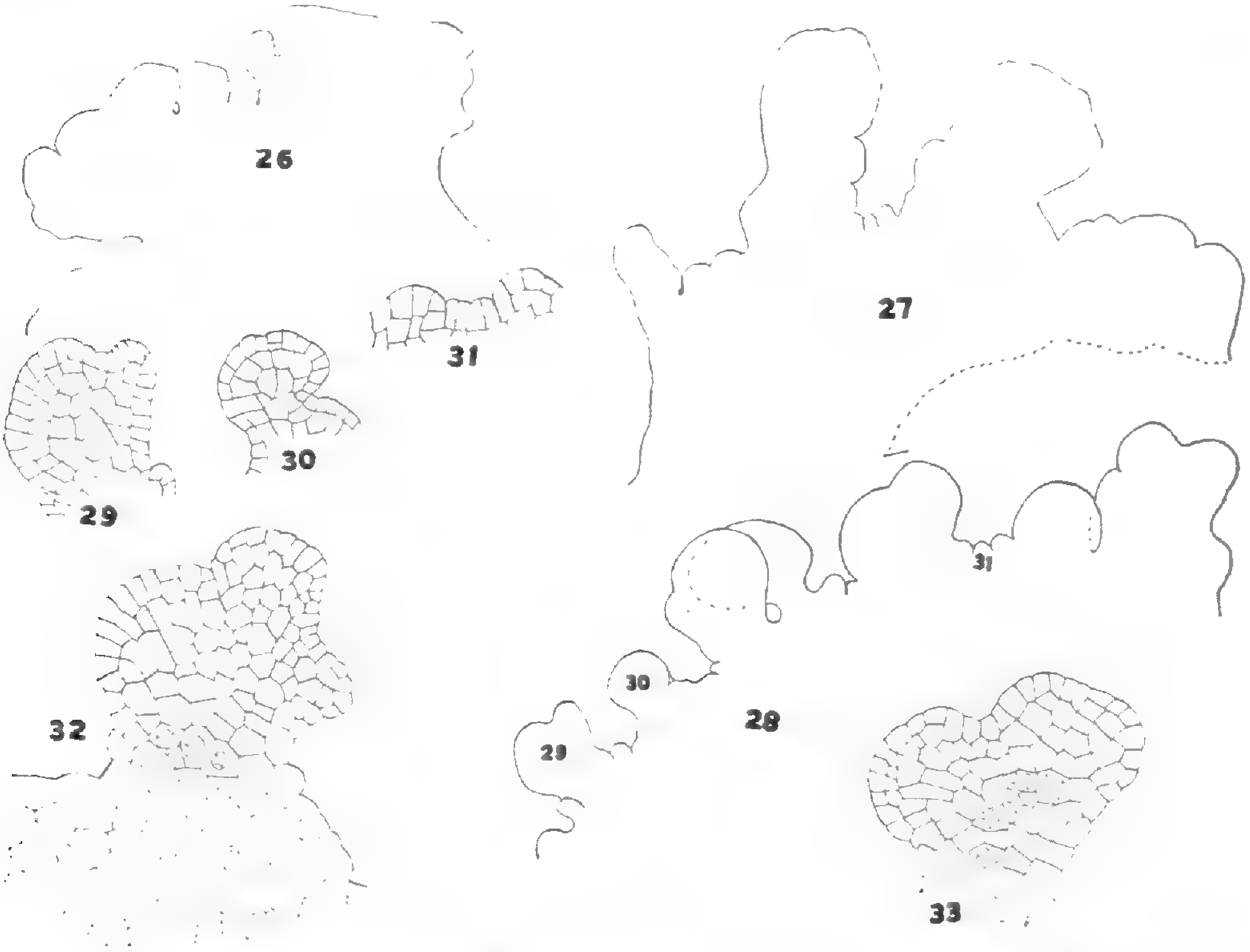
As far as the writer has been able to find there is no previous record of the survival of such extreme desiccation by fern prothallia or sporophytes. Attention has already been called to the importance of such ability to survive difficult conditions in the preservation of two other species of ferns, *Camptosorus rhizophyllus*, and *Asplenium platyneuron*. No doubt, in the case of *C. gracillima*, this peculiarity is an important factor, if not indeed the most important, in making possible the growth of this fern on the buttes of southeastern Washington, and in the even more arid regions in the southern portion of its range.

In December, 1922, experiments were carried on to determine the ability of these prothallia to withstand low temperatures. Dry prothallia were uninjured by an exposure of two weeks to temperatures ranging from 35° F. to − 10° F. Cultures of vigorous growing plants on moist soil showed considerable injury through exposure to the same conditions, although a few plants survived. The finding of a small number of prothallia on Kamiak Butte in April, 1923, prothallia too large to have developed this year, is evidence that they do survive the winter-conditions in this locality.

Seemingly closely connected with the hardy qualities of other ferns studied, is the tendency to develop outgrowths on old prothallia. This form of vegetative propagation is commonly found in old cultures of *C. gracillima*. As already mentioned various marginal or submarginal groups of cells, in no way related to the apical sinus or group, renew their meristematic characteristics and produce various forms of outgrowths. This tendency is more strongly developed in *C. gracillima* than in other forms studied. FIGS. 26, 27 and 28 show margins almost wholly given over to this peculiar growth. In old cultures prothallia sometimes show a marked crenulate and ruffled appearance produced by the abundance of these outgrowths.

Even young plants show much more ready branching, leading to the formation of plural growing areas, than is usual, as shown by Figs. 17, 18, 19, 20, 21, 22 and 23. The plants in Fig. 22 had been injured before the two outgrowths were formed, that in Fig. 23 was grown under normal conditions on the surface of a culture solution.

Another peculiar type of proliferation was observed. In old archegonial prothallia grown without the possibility of fertilization, marginal cells in the sinus showed the unusual size and arrangement illustrated in Fig. 24. This, as well as some other peculiar structures on old archegonial prothallia, suggests a type of apogamous embryo development; but no embryo that could be definitely assigned to apogamous origin has as yet been observed in this species.



Figs. 26–28. Marginal proliferation of old prothallia. Figs. 29–33. Cellular details of marginal growths; the small numbers on Fig. 28 show the position of Figs. 29–31.

These outgrowths in general behave as normal prothallia, producing rhizoids, antheridia and archegonia. As might be expected, the monosexual character of the old prothallia is carried into these outgrowths. The formation of marginal structures is so like the development of new tissue by injured liverworts as to be quite striking. FIGS. 29–33 show various types.

From work so far done the seasonal history of *C. gracillima* is as follows:—In the early spring sterile fronds are produced. These are followed in June by fertile fronds. The spores are matured before the winter's moisture has entirely left the scant soil in the rock crevices where the fronds grow. Aside from periods of very slight showers the fern remains inactive until late summer or early autumn. The fronds become dry and curl up closely, but, contrary to the usual habit of ferns, they do not lose their spores. With the coming of the first autumn rains, alternating with days of bright, warm sunshine and dry winds, the sporangia open and the spores are scattered. These spores germinate during the brief periods of sufficient moisture and lie quiescent during periods of drought, and so through considerable, broken growth-periods they are able to reach maturity and produce sporophytes. This may take place through the fall, winter and succeeding spring, or the prothallia are capable of living through one dry summer season before producing any sporophytes.

SUMMARY

In conclusion the following points should be noted. *Cheilanthes gracillima* is a typical xerophytic fern, owing its distribution and maintenance of habitat to a great extent to peculiarities of the gametophyte generation.

Spores and prothallia of this fern survive long periods of desiccation without any evidence of means for preventing the loss of water. Spores are retained after maturity until fall or winter.

Prothallia are strictly dioecious with marked differences in form and size of antheridial and archegonial plants.

Prothallia survive the usual winter conditions of eastern Washington. Marked development of vegetative propagation of prothallia is shown.

All figures used are from camera lucida drawings. FIGS. 26–33 are from drawings by Miss Lotta Dueber, a graduate fellow in the Botany Department for the year 1922–23. Miss Dueber should also be given credit for her care of cultures during that year. The other figures used are from the author's drawings.

THE STATE COLLEGE OF WASHINGTON,
PULLMAN, WASHINGTON

INDEX TO AMERICAN BOTANICAL LITERATURE
1923

The aim of this Index is to include all current botanical literature written by Americans, published in America, or based upon American material; the word America being used in the broadest sense.

Reviews, and papers that relate exclusively to forestry, agriculture, horticulture, manufactured products of vegetable origin, or laboratory methods are not included, and no attempt is made to index the literature of bacteriology. An occasional exception is made in favor of some paper appearing in an American periodical which is devoted wholly to botany. Reprints are not mentioned unless they differ from the original in some important particular. If users of the Index will call the attention of the editor to errors or omissions, their kindness will be appreciated.

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Adams, J. The effect on certain plants of altering the daily period of light. Ann. Bot. **37:** 75–94. Ja 1923.

Arber, A. On the 'squamulae intravaginales' of the Helobieae. Ann. Bot. **37:** 31–42. *f. 1–5.* Ja 1923.

Benedict, R. C. New bud sports in *Nephrolepis.* Genetics **8:** 75–95. *pl. 1, 2 + f. 1–4.* Ja 1923.

Benedict, R. C. Which Boston fern is best? Jour. Hered. **13:** 255–263. *f. 3–9.* 15 F 1923.

Bitter, G. Beiträge zur Kenntnis der Gattung *Sedum* I. Notizbl. Bot. Gart. und Mus. Berlin-Dahlem **8:** 281–284. 1 F 1923.

Includes *Sedum Nussbaumerianum*, sp. nov., from Mexico.

Clark, L. The embryogeny of *Podophyllum peltatum.* Univ. Minnesota Stud. Biol. Sci. 4: 111–138. *pl. 20–25 + f. 1–3.* Ja 1923.

Cook, O. F. Are any species uniform? Jour. Hered. **13:** 285–287. 15 F 1923.

Fairchild, D. Garden for the production of tropical and subtropical fruits. Science II. **57:** 167, 168. 9 F 1923.

Fawcett, W., & Rendle, A. B. Notes on Jamaican Ternstroemiaceae. Jour. Bot. **61:** 52–54. Ja 1923.

Fisher, W. K. Research in marine biology. Science II. **57:** 233–235. 23 F 1923.

Fritz, E. A plea for common sense in changes of botanical nomenclature. Jour. For. **21:** 61–63. Ja 1923.

Goodding, L. N. An interesting area of limber pine extending into southwestern Nebraska. Jour. For. **21:** 175, 176. F 1923.

Hayes, H. H. Inheritance in kernel and spike characters in crosses between varieties of *Triticum vulgare.* Univ. Minnesota Stud. Biol. Sci. 4: 162–184. Ja 1923.

Harlan, H. V., & Pope, M. N. Many-noded dwarf barley. Jour. Hered. **13:** 269–273. *f. 12–15.* 15 F 1923.

Hensel, R. L. Effect of burning on vegetation in Kansas pastures. Jour. Agr. Research **23:** 631–644. *pl. 1, 2 + f. 1–4.* 24 F 1923.

Herzog, T. Beiträge zur Bryophytenflora Chiles. Hedwigia **64:** 1–18. *f. 1–5.* 15 Ja 1923.
Includes 11 new species.

Hitchcock, A. S. Remarks on Mr. Sprague's suggestion. Science II. **57:** 209. 16 F 1923.
Concerning nomenclature.

Holbert, J. R., Burlison, W. L., Biggar, H. H., Koehler, B., Dungan, G. H., & Jenkins, M. T. Early vigor of maize plants and yield of grain as influenced by the corn root, stalk, and ear rot diseases. Jour. Agr. Research **23:** 583–630. *pl. 1, 7 + f. 1–20.* 24 F 1923.

Huff, N. L. Observations on the relation of algae to certain aquatic animals of Vaduais Lake. Univ. Minnesota Stud. Biol. Sci. 4: 185–197. *f. 1–3.* Ja 1923.

Hunter, O. W. Stimulating the growth of *Azotobacter* by aeration. Jour. Agr. Research **23:** 665–677. *f. 1–4.* 24 F 1923.

Johnson, A. M. A revision of the North American species of the section *Borophila* of the genus *Saxifraga.* Univ. Minnesota Stud. Biol. Sci. 4: 1–110. *pl. 1–19.* Ja 1923.
Includes 10 new species.

Keller, R. Über neue Artern der Gattung *Hypericum.* Bot. Jahrb. **58:** 190–192. 1 F 1923.
Includes *Hypericum Seleri*, sp. nov., from California.

Klett, W. *Pseudospigelia*, eine neue Gattung der Loganiaceae. Bot. Archiv **3:** 134–136. 15 F 1923.
From Guiana and Brazil.

Kohz, K. Sero-diagnotische Untersuchungen über die Verwandschaften innerhalb des Rosales-Astes der Dikotylen. Bot. Archiv **3:** 30–60. 15 Ja 1923.

Kraemer, H. The starch grain. Science II. **57:** 175. 9 F 1923.

Krause, K. Zur Kenntnis von *Philodendron Mamei* André und *Philodendron gloriosum* André. Notizbl. Bot. Gart. und Mus. Berlin-Dahlem **8:** 285, 286. 1 F 1923.
From Ecuador.

Lewis, F. T. A note on symmetry as a factor in the evolution of plants and animals. Am. Nat. **57:** 5–41. *f. 1–12.* F 1923.

Malloch, W. S. Value of the hemp plant for investigating sex inheritance. Jour. Hered. **13:** 277–283. *f. 16–22.* 15 F 1923.

Martin, G. W. What is a plant? Science II. **57:** 175, 176. 9 F 1923.

Maxon, W. R. The type-species of *Pteris.* Jour. Bot. **61:** 7–10. Ja 1923.

Möbius, M. Über die Färbung der Antheren und des Pollens. Ber. Deuts. Bot. Ges. **41:** 12–15. 22 F 1923.

Northrop, J. H., & DeKruif, P. H. The agglutination of bacteria. Science II. **57:** 224–227. 23 F 1923.

Palmer, E. J. The Red River forest at Fulton, Ark[ansas]. Jour. Arnold Arb. **4:** 8–32. 16 F 1923.

Pfeiffer, H. Vergleichende Anatomie der Blätter der *Lagenocarpus*-Arten. Beih. Bot. Centralbl. **39:** 436–445. *pl. 6.* 27 Ja 1923.

Pilger, R. Eine neue *Podocarpus*-Art aus Peru. Notizbl. Bot. Gart. und Mus. Berlin-Dahlem **8:** 273, 274. 1 F 1923.
Podocarpus Rospigliosii, sp. nov.

Ponce, L. P. Contribución al estudio del curá mamoel (*Colletia cruciata*, Gill. et Hook.). Rev. Facul. Cien. Quim. **1:** 183–264. *f. 1–8.* F 1923.

Rehder, A. Michaux's earliest note on American plants. Jour. Arnold Arb. **4:** 1–7. 16 F 1923.

Ridley, H. N. The distribution of plants. Ann. Bot. **37:** 1–30. Ja 1923.

Rimbach, A. Die Jahresperiode der Pflanzen bei Montevideo. Bot. Jahrb. **58:** 182–189. 1 F 1923.

Rossner, F. Untersuchungen über die Beziehungen zwischen Bestäubung und Blütendauer. Bot. Archiv. **3:** 61–128. 15 F 1923.

Sayre, J. D. Physiology of stomata of *Rumex patientia*. Science II. **57:** 205, 206. 16 F 1923.

Schmidt, O. C. Drei neue Phytolaccaceen aus Südamerika. Notizbl. Bot. Gart. und Mus. Berlin-Dahlem **8:** 312–314. 1 F 1923.

New species in *Phytolacca* (1), *Ledenbergia* (1), and *Schindleria* (1).

Schulz, O. E. Eine neue *Cardamine*-Art aus Costarica. Notizbl. Bot. Gart. und Mus. Berlin-Dahlem **8:** 328. 1 F 1923.

Cardamine Bradei, sp. nov.

Smith, F. E. V. On direct nuclear divisions in the vegetative mycelium of *Saprolegnia*. Ann. Bot. **37:** 63–74. *f. 1–12.* Ja 1923.

Souèges, R. Recherches sur l'embryogénie des Solanacées. Bull. Soc. Bot. France **69:** 352–365. *f. 53–125.* 1922; 555–585. *f. 126–259.* Ja 1923.

Sprague, T. A. Comma between name and authority. Jour. Bot. **61:** 26. Ja 1923.

Sprague, T. A. *Rinorea* and *Riana*. Jour. Bot. **61:** 27. Ja 1923.

Sprague, T. A. Suggestions for a world-code of plant nomenclature. Science II. **57:** 207, 208. 16 F 1923.

Vol. 50 No. 11

BULLETIN

OF THE

TORREY BOTANICAL CLUB

NOVEMBER, 1923

Notes on Carex—XIII

KENNETH K. MACKENZIE

1. THE IDENTITY OF CAREX GOODENOWII J. GAY AND CAREX ACUTA L.

One of the most widely distributed and best known species of *Carex* is the plant which in recent years has been known as *Carex Goodenowii* J. Gay, or sometimes as *Carex vulgaris* Fries. Prior to 1839 this very common European species had been almost universally treated by authors as *Carex caespitosa* L., but in that year J. Gay (Ann. Sc. Nat. II. **11**: 191) drew attention to the fact that *Carex caespitosa* L. was in fact a closely related but entirely distinct species. At the same time he gave the name *Carex Goodenowii* to the species which had been passing as *Carex caespitosa* L.; and, as stated above, he has been largely followed by subsequent authors.

Investigation since his time, however, has shown that a number of species were proposed after Linnaeus and before 1839 which are the same as *Carex Goodenowii*, and in all probability one of these names would have to be taken up, if it were not for the facts hereinafter referred to. Names which would require careful investigation are *Carex alpina* Honck (1792), *Carex ambigua* Moench (1794), *Carex polyandra* Schkuhr

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[The BULLETIN for October (**50**: 317–342. *pl. 19*) was issued November 19, 1923.]

(1801), *Carex Moenchiana* Wender (1823), *Carex angustifolia* Smith (1828), and *Carex stolonifera* Hoppe (1835)*.

But before taking up the question of the availability of any of the above names, the question of the proper use of the name *Carex acuta* L. had to be decided, and certain facts were brought to light which have left no doubt in my mind that this name should be applied to the plant known as *Carex Goodenowii* J. Gay.

The original description of *Carex acuta* L. (Sp. Pl. 978. 1753) is as follows:

acuta. 28. CAREX spicis masculis pluribus, femineis subsessilibus, capsulis obtusiusculis. *Fl. suec.* 769. *Dalib. paris.* 281.

Carex spicis erectis oblongis sessilibus alternis foliolo florali brevioribus: superioribus masculis. *Hort. cliff.* 439. *Roy. lugdb.* 74.

nigra. α. Carex nigra verna vulgaris. *Fl. lapp.* 330.

Gramen Cyperoides, foliis cariophyllaeis, vulgatissimum. *Raj. hist.* 1292.

ruffa. β. Carex spicis masculis superioribus numerosis, femineis inferioribus: intermedia unica androgyna. *Roy. lugdb.* 75.

Carex maxima, spicis plurimis remotis longis. *Fl. lapp.* 329.

Cyperoides foliis caryophyllaeis, spicis habitioribus: squamis curtis. *Mich. gen.* 62. *t.* 32. *f.* 12.

Cyperoides latifolium, spica ruffa f. caule triangulo. *Scheuch. gram.* 458.

Gramen Cyperoides spica ruffa, f. caule triangulo. *Bauh. pin.* 6.

Habitat in Europa *ubique: α. in siccioribus, β. in aquosis.* ♃.

It has long been known that the species as so described is a complex, but European authors have usually applied the name *Carex acuta* to the second element, namely, the variety *ruffa* L. (*Carex gracilis* Curt.). That the name, however, belongs to the first element, namely, the variety *nigra* L., which is universally admitted to be the same plant as *Carex Goodenowii* J. Gay, has occurred to certain European authors, with the result that

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* Also to be considered is *Carex fusca* All. (Fl. Pedem. **2**: 269. 1785), a species based solely upon Haller's No. 1378 and a reference to Scheuchzer. The reference to Scheuchzer was taken from Haller, whose number 1378 has been identified with the *Carex caespitosa* of authors (Steud. Nomen., Ed. 2, **1**: 298).

it has been so used by Sanio (Bot. Centralbl. **6:** 438. 1881). Kükenthal, the latest author to deal with the question, followed the German habit in dealing with puzzling names and gave the name up altogether (Pflanzenreich **4**^{20}**:** 313, 319. 1909).

In addition to the fact that the variety *nigra* is given ahead of the variety *ruffa* by Linnaeus, there are two other facts which European authors have not referred to, as far as I know, which are of much importance in settling the proper use of the name, as follows:

1. The description in the Species Plantarum is very largely copied by Linnaeus from his earlier work, the Flora Suecica, with the very important change that he reversed the order of the varieties. In other words the descriptive phrases, which in the Species Plantarum are used as the foundation for the variety *nigra*, are given in the earlier Flora Suecica after the descriptive phrases, which in the Species Plantarum are used as the foundation for the variety *ruffa*. And these phrases in the Flora Suecica are separated as varieties α and β in reversed order from that followed by the author in his later work, when he came to apply the binomial system. He could hardly have shown more strongly what plant he had primarily in mind when he coined the name *Carex acuta*.

2. It can readily be seen that Linnaeus took the names of his varieties *nigra* and *ruffa* from the older descriptive phrases cited by him, but the name *acuta* is not taken from any of these descriptive phrases, and it was not until I looked up the description of *Carex nigra verna vulgaris*, given by him in Flora Lapponica, page 257, that I found the undoubted source of the name in the following short observation:

> Agricolis Nouaccolis minus arrident prata gramine hocce referta, dum foenu vilioris notae suppeditant, nec pinguescat bos carice pastus acuta.

I cannot therefore escape the conclusion that the name *Carex acuta* L. must be used for the plant known before 1753 as *Carex nigra verna vulgaris*. This latter plant has universally been treated by authors as undoubtedly the same as the more recent *Carex Goodenowii* J. Gay, a conclusion which I see no reason to doubt (see Fries, Nov. Mant. **3:** 153; Holm, Am. Jour. Sci. IV. **17:** 306; Kükenthal, Pflanzenreich **4**^{20}**:** 313).

2. CONCERNING CAREX MURICATA L.

The original description of *Carex muricata* L. (Sp. Pl. 974. 1753) is as follows:

muricata. 8. CAREX spiculis subovatis sessilibus remotis androgynis, capsulis acutis divergentibus spinosis. *Fl. suec.* 752. *Gmel. sib.* 1. *p.* 148.
Carex spica androgyna, spiculis compactis obscure alternis, culmo nudo compresso. *Gvett. stamp.* 1. *p.* 149.
Carex nemorosa, fibrosa radice, angustifolia minima, caule exquisite triangulari, spica brevi interrupta. *Mich. gen.* 69. *t.* 33. *f.* 11.
Gramen Cyperoides spicatum minimum, spica divulsa aculeata. *Scheuch. gram.* 485.
Gramen nemorosum, spicis parvis asperis. *Bauh. pin.* 7. *Moris. hist.* 3. *p.* 244. *f.* 8. *t.* 12. *f.* 27.
Habitat in Europae *nemoribus humentibus.* ♃.

It will be noted that the first reference by Linnaeus is to the Flora Suecica, and it is the only reference to his own works. There the Linnaean description is nearly the same as in the Species Plantarum, but there is additional information given. The full description (Fl. Suec. 272. 1745) is as follows:

752. CAREX spiculis subovatis sessilibus distinctis androgynis, capsulis acutis divergentibus aculeatis.
Carex nemorosa, fibrosa radice, angustifolia minima, caule exquisite triangulari, spica brevi interrupta. *Mich. gen.* 69. *t.* 33. *f.* 11, 12.
Carex spicis brevibus echinatis sessilibus distinctis. *Hall. helv.* 245.
Scirpoides, spica laxa, minus. *Mont. gram.* 17.
Gramen cyperoides spicatum minimum, spica divulsa aculeata. *Raj. hist.* 1298. *Scheuch. hist.* 485. *t.* 11. *f.* 3.
Gramen nemorosum, spicis parvis asperis. *Bauh. pin.* 7. theatr. 100. *Moris. hist.* 3. *p.* 244. *f.* 8. *t.* 12. *f.* 26.
Suecis. Pigg-starr.
Habitat *in udis nemorosis umbrosis praeserlim* Norlandiae,

The botanists immediately following Linnaeus seem to have been quite unanimous in applying the name *Carex muricata* to what has in more recent times usually been called *Carex stellulata* Good. It is so illustrated in Flora Danica (*pl. 284*), and is so used by Leers (Fl. Herborn. 196. 1775), by Hudson (Fl. Angl. ed. 2, 406. 1778), and by Lightfoot (Fl. Scot. **2**: 549. 1777). There never has been any doubt that the plant of wet places, which occurs especially in northern Sweden and which is undoubtedly to be taken as the type of *Carex muricata*, is the same as *Carex stellulata* L. (see Wahlenb. Fl. Lapp. 231).

The use of the name in recent years for a dry ground European species with the staminate flowers uppermost in the spikes seems to have come about partly from the fact that there was a mixture in the Linnaean herbarium (Kükenthal, Pflanzenreich **4**^{20}: 156), and partly from the fact that some of the names of the older writers quoted by Linnaeus undoubtedly referred to some of the species with staminate flowers uppermost. Of this group, there are four European species to be considered. Two of these, *Carex contigua* Hoppe (*Carex muricata* of American authors) and *Carex divulsa* Good., can be at once eliminated as they do not agree with the Linnaean description "capsulis acutis divergentibus." The other two, *Carex Pairaei* F. Schultz and *Carex Leersii* F. Schultz, do not occur in northern Sweden and, I believe, are not plants of wet places at all.

Of the plates cited by Linnaeus the one in Scheuchzer is of *Carex stellulata* Good., and the one in Micheli looks like *Carex Pairaei* F. Schultz. I have not seen the other plate cited. However, what we are really concerned with is with Linnaeus' own Swedish plant, and his synonymy is not at all controlling.

The correct use of the name *Carex muricata* L. has been known in Europe right along, and I am sure that there must be a considerable number of references to it in the European literature. One, which I have come across, is as follows: "Nostra e silvis est *C. muricata* Good. non Linnaei. *C. stellulata* Good. autem est *muricata* Linn. in paludibus crescens." See Kitaibel; Kanitz, Linnaea **32**: 317. 1863.

The distinguished German author Kükenthal refers to the troubles connected with the name in Engler Pflanzenreich (**4**^{20}: 156), and like the Roman senator of old with the cry "Delenda est Carthago" emphatically announces "quare istud nomen delendum est." Following this he abandons the use of the name altogether. This German practice of suppressing Linnaean names, where Linnaeus had some mixture, is to be most strongly condemned. The fact is that there is a mixture in a great many of the Linnaean species, and to apply the German practice logically to all cases would result in the displacement of a great number of names. The only proper course to pursue is to apply the type method, and in the present case that requires the use of the name *Carex muricata* L. for *Carex echinata* Murr. (*Carex Leersii* Willd.; *Carex stellulata* Good.).

3. CAREX BIPARTITA ALL.

The original description of *Carex bipartita* (All. Fl. Pedem. **2:** 265. 1785) is as follows:

> 2301. Carex bipartita tab. 89. fig. 5.
>
> *Carex culmo tereti nudo, spicis binis terminalibus, suprema composita.*
>
> Loc. In alpibus *d'Ussey*, & in monte *Cenisio* locis uliginosis reperit *Cl.* Bellardi.
>
> *Perennis.*
>
> *Descr.* Radix fibrosa cespitem praebet, ex quo aliquot culmi prodeunt recti, nudi. Culmus foliis duplo altior, vix palmaris, striatis, teres. Folia graminea, glabra, parum convoluta, striata, acuta, fere pungentia. Spica terminalis etiam uncialis, composita ex spiculis sessilibus, alternis congestis, altera spica distincta subjacet simplex foliolo insidens. Spicula infima foliolo insidet spadiceo acuto, & ab aliis paullisper distat. Raro tertia spicula inferius nascitur. Glumae ovatae, acutae, non aristatae, fuscae, ora per aetatem albescente.

Pl. 89, f. 5, shows two culms on each of which there are two closely approximate spikes. The culms are twice the length of the leaves. The leaves are bunched near the base; the blades are nearly flat, and the lower ones are much reduced. The species is placed by Allioni in the group with "spicis pluribus androgynis," consisting mostly of various well-known European species of *Vignea*.

This species was unhappily identified by Bailey (Mem. Torrey Club **1:** 63. 1889) with *Kobresia caricina* Willd., on the basis of some specimens in Allioni's herbarium. Following this identification the name *Kobresia bipartita* came into use. Neither Allioni's description nor his plate apply at all to the *Kobresia*, and it is evident that there was some misplacement of specimens. Holm has drawn attention to this (Am. Jour. Sci. **15:** 145–152. 1903), and the name has ceased to be used for the *Kobresia*.

However, it was years ago pointed out by Gay (Ann. Soc. Nat. Bot. II. **11:** 177. 1839) that Allioni's description and plate applied well to *Carex lagopina* Wahlenb. Further, Bellardi's plant, on which *C. bipartita* was based, has been verified as *Carex lagopina* by Parlatore (Fl. It. **2:** 141, 161), and that author treated *Carex bipartita* as the same as *Carex lagopina*. It would seem that the evidence is quite clear, and that we should use the oldest name, *Carex bipartita*, instead of either the later *Carex Lachenalii* Schkuhr or the still later *Carex lagopina* Wahlenb.

The only other European species of *Carex* to which the description and figure of Allioni could apply is *Carex Heleonastes* L. f., and this species is not involved. It is difficult, indeed, to understand how Holm after carefully giving the above facts should write, "we regret to say that we have not succeeded in determining the identity of this second species of Allioni with absolute certainty." One would say that the evidence is much more complete than with a great number of names in use.

4. New names

Kobresia simpliciuscula (Wahlenb.) Mackenzie, comb. nov.

Carex simpliciuscula Wahlenb. Vet.-Akad. Nya Handl. Stockholm 141. 1803.

Kobresia caricina Willd. Sp. Pl. **4:** 206. 1805.

It is curious that the above combination does not seem to have been made. In the Pflanzenreich (4^{20}: 45) Kükenthal refers the name *Carex simpliciuscula* to *Kobresia* with a question mark and adds "fide A. Bennett." However, when it came to excluding the species from *Carex* all doubt disappeared, and on page 765 the two plants are treated as identical without question.

What Bennett really says (Jour. Bot. **35:** 263. 1897) is as follows:

> In Vet. Ak. Handl. 141 (1803) (Act. Holm) Wahlenberg describes a *Carex simpliciuscula* from 'Westmoreland, Anglia.' Sprengel puts this to *Kobresia caricina* Willd. and Kunth quotes Sprengel; by the kindness of Dr. Almquist I am able to say this is correct, as he has examined the specimen for me in the Herb. Vet. Ak. Stockholm.

The correct name for the *Kobresia* would seem to be entirely clear.

✓**Carex hirsutella** Mackenzie, nom. nov.

Carex hirsuta Willd. Sp. Pl. **4:** 252. 1805. Not *C. hirsuta* Suter., 1802.

Carex triceps Michx. var. *hirsuta* Bailey, Mem. Torrey Club **1:** 35. 1889.

5. A calciphile sedge closely allied to a non-calciphile species

Carex Muhlenbergii Schkuhr is usually a plant of very sterile sandy wastes. It is found from Maine to Florida and in the

Gulf States west to Texas, and it also occurs around the Great Lakes and very locally in other parts of the interior in suitable habitats. It is best developed on the coastal plain but has pushed its way inland and is found at times on dry hills. It is marked by having perigynia strongly many-ribbed both dorsally and ventrally, and the perigynia are also slightly convex ventrally and have slightly elevated margins. The ligule is usually very short, and the leaves are often markedly roughened above.

The plant described by Boott as *Carex Muhlenbergii* var. *enervis*, on the other hand, is a species of dry hillsides, and is best developed in the calcareous regions of the interior. In it the perigynia are nerveless ventrally or obsoletely nerved at the base, and are much less prominently and much fewer ribbed dorsally. The perigynia also are not convex ventrally and the margins are not elevated at the base. The perigynia also average smaller and narrower than do those of *Carex Muhlenbergii;* the ligule is more pronounced, and the leaves tend to be smoother above. Growing in much richer soil than *Carex Muhlenbergii* it is a strong, vigorous plant, and the starved and stunted appearance, which one learns to associate with *Carex Muhlenbergii,* is entirely wanting.

The Mexican *Carex xalapensis* Kunth, to which the plant of the United States has been referred, is a very similar species, but in it the scales are tinged with reddish- or yellowish-brown, the teeth of the beaks of the perigynia are less spreading, and the beaks are reddish-brown tinged; the perigynia are inconspicuously nerved dorsally, and the leaf-blades are much more smooth.

It would seem best to treat a plant as well characterized as the above and with such a marked difference in range as a species, as follows:

Carex plana Mackenzie, sp. nov.

Carex Muhlenbergii Schkuhr var. *enervis* Boott, Ill. Car. **3:** 124, *pl. 400.* 1862. TYPE from Highlands, New York; not *C. enervis* C. A. Meyer, 1833.

Carex Muhlenbergii var. *xalapensis* Britton, in Britton & Brown, Ill. Fl. **1:** 349. 1896 (as to plant described only).

Cespitose from lignescent short-prolonged dark fibrillose rootstocks, the culms 3–9 dm. high, slender, but stiff, sharply triangular, rough above, leafy on lower fifth, much exceeding the leaves, light brownish at base, the dried-up leaves of the first year conspicuous; leaves with well-developed blades five to ten to a culm, the blades erect-ascending, thickish, green, 2–3 mm. wide, usually 1–3 dm. long, flat or channeled at base, long-tapering, roughened towards apex and on the margins, the sheaths tight, not septate-nodulose, not or but little cross-rugulose, concave or truncate, and thickened and yellowish-brown tinged at mouth, the ligule conspicuous, somewhat wider than long; spikes five to ten, androgynous, densely aggregated into an oblong head, 2–4 cm. long, 8–10 mm. wide, the lower at least well-defined and distinguishable, the staminate flowers few with ovate-lanceolate cuspidate scales, the eight to twenty perigynia ascending or at length spreading; bracts bristleform, short but at least the lowest conspicuous; scales ovate, greenish hyaline with three-nerved green center, cuspidate or aristate, narrower than and (excluding awn) from somewhat shorter than to about length of body of perigynia; perigynia 3–3.5 mm. long, 2–2.25 mm. wide, ovate, broadest below middle and round-tapering and slightly spongy at base, subcoriaceous, light green or in age yellowish-green, plano-convex, several- to rather many-ribbed dorsally, nerveless or short nerved at base ventrally, flat or nearly so ventrally, serrulate from above the middle, abruptly short-beaked, the beak 1 mm. long, rather widely bidentate with short-triangular teeth, hyaline within, both sutures conspicuous; achenes lenticular, ovoid-orbicular, 2 mm. long, 1.75 mm. wide, filling perigynia, abruptly substipitate, very short apiculate; style short, slender, enlarged at base, jointed with achene; stigmas two, reddish-brown, slender.

TYPE LOCALITY: Highlands, Hudson River, New York, *Russell;* figured by Boott as *C. Muhlenbergii* var. *enervis* Boott, on which *C. plana* is based.

SPECIMENS EXAMINED*

MAINE: York, *Fernald & Long 13009* (P.).

MASSACHUSETTS: Hingham, Plymouth County, *Knowlton* (P.,N.E.); "Mass." *Dewey* (P.); Malden, *W. Boott* (H.); Stockbridge, *Dewey* (H.).

CONNECTICUT: Waterford, *Graves 212* (H.); Stamford, "*A.W.D.*" (H.); New Haven, *Woodward* (N.E.); Waterbury, *Blewitt 270* (N.E.); Cheshire, *Bissell* (N.E.); North Branford, *Dudley* (N.E.).

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* Specimens in this paper are cited from herbaria as follows: Columbia University (Col.); Gray Herbarium, Harvard University (H.); K. K. Mackenzie (K.M.); New England Botanical Club (N.E.); New York Botanical Garden (N.Y.): Philadelphia Academy of Natural Sciences (P.).

NEW YORK: Flushing, *Thurber* (H.); Phillipston, *Barratt* (H.); Yonkers, *E. C. Howe* (H.); Ithaca, *H. B. Lord* (H.).

NEW JERSEY: Byram, *Best* (P.); Ogdensburg, Sussex County, *Mackenzie 4609* (K.M.); Pompton, Passaic County, *Mackenzie 2686* (K.M.); Phillipsburg, Warren County, *Mackenzie 4895* (K.M.); Closter, *Austin* (H.).

PENNSYLVANIA: Chestnut Hill, Easton, *Porter* (numerous collections, P.H.); Lehigh County, *Pretz* (P.) as follows: Emaus *6592*, Lowhill *4656*, Allentown *9698*, Locust Valley *9371*, Slatington *9772*, Old Zionsville *8132*, New Tripoli *8778*, Limeport *6691*, and Kernsville *6987;* Moslem Springs, Berks County, *Long 12752* (P.); Lobachsville, Berks County, *Long 12643* (P.); Rockhill, Bucks County, *Fretz* (P.); Narrowsville, Bucks County, *Long* (P.); Bethlehem, *Schweinitz* (P.); Philadelphia, *Canby* (P.); also *Leidy* (P.); Wawa, Delaware County, *Pennell 11* (P.); Crum Creek, Delaware County, *Van Pelt* (P.); Byberry, *Martindale* (P.); Valley Forge, Chester County, *Long 983*, *984* (P., K.M.); Lancaster County, *Porter* (P.).

DELAWARE: Centreville, *Commons* (P.); Wilmington, *Commons* (P.); also *Canby* (H.).

MARYLAND: Oakwood Township, Cecil County, *Pennell 1580* (P.); Pataxent, Anne Arundel County, *Painter 1397* (H.).

DISTRICT OF COLUMBIA: Washington, *Steele* (K.M.); High Island, *Hicks* (H.); Washington, *Holm* (H.).

OHIO: Catawba Island, Ottawa County, *Moseley* (H.).

MICHIGAN: Tawas Point, *Gillman* (H.).

INDIANA: Central, Harrison County, *Deam 20502* (K.M.); Leavenworth, Crawford County, *Deam 23465* (K.M.); Vernon, Jennings County, *Deam 24715* (K.M.); Forest Reserve, Clark County, *Deam 27624* (K.M.); Huntingburg, Dubois County, *Deam 8399* (K.M.); Cannelton, Perry County, *Deam 24943* (K.M.).

ILLINOIS: Stevens Creek, Macon County, *Clokey 2269* (K.M., H.).

TENNESSEE: Memphis, *Palmer 17515* (H.); Lookout Mountain, *Churchill* (H.).

MISSOURI: Meremac Highlands, *Bartram 1444* (P.); Martin City, Jackson County, *Mackenzie* (K.M.); Courtney, Jackson County, *Bush 173* (K.M., H.) and *2001* (K.M.); Eolia, *Davis 8874* (K.M.); Noel, *Bush 5051* (K.M.); Swan, *Bush 2921*, *4512, 4750* (K.M.); Monteer, *Bush 2872, 2777, 4739* (K.M.); Webb City, *Bush 1642* (K.M.); Jefferson Barracks *Glatfelter* (K.M.); St. Louis, *Glatfelter* (K.M.); Eagle Rock, Barry County, *Mackenzie* (K.M.); London, Ozark Mountains, *Lansing 2932* (H.); Klondike, *Bush 2207* (H.); Blue Springs, *Bush 6981* (H.).

ARKANSAS: Miller County, *Bush 2394* (K.M.).

OKLAHOMA: Waynoka, Woods County, *Stevens 571½* (H.).

TEXAS: Handley, Tarrant County, *Ruth 710* (K.M.); Dallas, *Reverchon 2390* (K.M., H.); Waco, *Tyler* (H.).

6. CONCERNING CAREX XANTHOCARPA BICKNELL

In one of those keenly analytical papers which have served so well to clear up problems connected with difficult groups of plants Bicknell in 1896 proposed a new species, *Carex xanthocarpa,* with a variety *annectens.* The fact that the very appropriate specific name selected was in use in Europe for a plant probably of hybrid origin was later brought to his attention, but he contented himself with raising his variety *annectens* to specific rank in 1908 without further reference to his *Carex xanthocarpa.* Fernald, meantime, in 1906, having noticed that the poorly appreciated *Carex vulpinoidea* var. *ambigua* Barratt had the same short beaked perigynia as Bicknell's plant, had taken up this varietal name under *Carex setacea* Dewey. Under this name it appears in the seventh edition of Gray's Manual, *Carex xanthocarpa* being given as a synonym and no reference being made to the variety *annectens.* In 1909 Kükenthal, in the Pflanzenreich, took up Bicknell's *Carex xanthocarpa* as a variety under *Carex vulpinoidea* and treated var. *annectens* as a forma. Finally, in 1913, I treated both *Carex xanthocarpa* and *Carex annectens* under the name *Carex annectens*, and this treatment has been quite generally followed. The above completes the nomenclatural history of these plants until very recently, with the exception that a European botanist, E. G. Camus, noting that *Carex xanthocarpa* Bicknell had been previously used, gave to Bicknell's plant the name *Carex Bicknellii*, overlooking however the fact that the name *Carex Bicknellii* was in use for another American species.

Very recently Wiegand* again called attention to certain of the points of difference between the two plants of Bicknell, and in a miraculous nomenclatural shuffle was able to apply the invalid name *Carex xanthocarpa* as a varietal name under *Carex annectens*.

One of the groups very well represented in the great collection of local material at the Philadelphia Academy of Natural Sciences is the present one, and this collection has helped greatly in the present study. *Carex annectens*, as stated by Wiegand, turns out to be a plant principally of the Atlantic seaboard, extending from central Maine to North Carolina. It is a species of sterile soils and is often abundant in poor pastures or old fields. It gets up along the rivers and occurs sparingly in the Great Lake region and occasionally elsewhere in the interior, but it certainly very rapidly disappears as one gets away from the coastal plain. *Carex xanthocarpa* Bicknell, on the other hand, turns out to be a very widely distributed species. It is apparently a southern species which is pushing northward. On the Atlantic seaboard it has reached as far north and east as Maine and central New York, and in the Mississippi Valley as far as Ohio and Illinois. It is more largely a plant of limestone regions, but both it and *Carex annectens* are weedy plants and are probably to a considerable extent introduced in pastures.

The abundant material of *Carex annectens* and *Carex xanthocarpa* Bicknell now before me has disclosed that these plants can be distinguished not only by the characters brought out by Bicknell but also by characters taken from the mouth of the sheath and the ligule of the upper leaves. In *Carex annectens* the ventral prolongation of the sheath at its mouth is high convex and about as long as wide, even in the upper leaves. This is well brought out in Boott's plate 406. On the other hand, in *Carex xanthocarpa* Bicknell, the sheaths of the upper leaves are almost invariably truncate or low-concave at mouth and the prolongation, if any, is very much wider than long.

In *Carex annectens* the ligule is also as a rule much less developed than it is in *Carex xanthocarpa*. As pointed out by Bicknell and Wiegand, *Carex annectens* at maturity has a dull yellowish look and the heads have a markedly echinate appear-

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*Rhodora **24**: 73, 74. 1922.

ance from the long awns of the scales. The perigynia average markedly wider than those of *Carex xanthocarpa*. They are usually, although not always, somewhat longer, strongly nerved dorsally, more strongly serrulate above and more markedly green-margined above and sharply bidentate. *Carex xanthocarpa* Bicknell has more obscurely bidentate perigynia which are narrower and usually shorter, being mostly but 2.2–2.6 mm. in length. They are normally nerveless or obscurely few-nerved dorsally, although occasionally plainly several-nerved. At maturity they are golden-yellow and but little green-margined above, and are but rarely exceeded by the awns of the scales. The heads average shorter than in *Carex annectens* but are markedly less echinate in appearance.

The very close similarity between depauperate specimens of *Carex annectens* and *Carex Muhlenbergii* has been more than once remarked. But as Dr. Britton once said to me, "there are tricks in all trades," as he happily proceeded to name a leaf-specimen of *Prunus* from gland characters. And the "trick" employed by a *Carex* student in naming poor material of the above species lies in examining the mouth of the sheath. In *Carex Muhlenbergii* this is strongly hollowed downward or concave, while in *Carex annectens* and its relatives it is prolonged upward and convex at least in the lower sheaths. The reddish dots found on the ventral side of the sheath (at least at the upper edge) in *Carex annectens* are not found in *Carex Muhlenbergii*.

As the name *Carex xanthocarpa* can not be used I am proposing to deal with this species as follows:

Carex brachyglossa Mackenzie, nom. nov.

Carex xanthocarpa Bicknell, Bull. Torrey Club **23:** 22. 1896 TYPE from New York; not *C. xanthocarpa* Degl., 1807.

Carex vulpinoidea Michx. var. *xanthocarpa* Kükenthal; Engler's Pflanzenreich **4**^{20}**:** 148. 1909. Based on *C. xanthocarpa* Bicknell.

Carex Bicknellii E. G. Camus; Lecomte, Not. Syst. 1:239. 1910. Based on *C. xanthocarpa* Bicknell; not *C. Bicknellii* Britton, 1896.

Carex annectens Bicknell var. *xanthocarpa* Wiegand, Rhodora **24:** 74. 1922. Based on *C. xanthocarpa* Bicknell.

Cespitose, the rootstocks very short-prolonged, stout, tough, fibrillose, blackish, the culms 3–10 dm. high, exceeding the leaves, very rarely shorter, stiff but slender, 2.5–4.5 mm. thick at base, acutely triangular above with flat sides, obtusely triangular below, roughened beneath the head, brownish at base, the lower leaves reduced, the dried-up leaves of the previous year conspicuous; leaves with well-developed blades three to six to a culm, on the lower third but not bunched, the blades erect-ascending, flat or slightly canaliculate, light-green, thinnish but rather firm, 3–6 mm. wide, 2–4 dm. long, long-tapering, roughened on the margins and towards the apex, the sheaths tight, thin, cross-rugulose, red-dotted and greenish-white ventrally, short-prolonged upward beyond base of blade and truncate or slightly convex at mouth and slightly thickened and yellowish, the ligule nearly as long as wide; spikes very numerous or numerous in a more or less compound terminal head, 2–7 cm. (usually 3–5 cm.) long, 8–15 mm. thick, narrowly oblong-ovoid, the lower clusters not separated and usually not strongly compound, the upper densely aggregated; heads greenish-yellow when young, golden-brown when mature, the individual spikes distinguished with difficulty; staminate flowers apical, inconspicuous, with the several–many ascending or at maturity spreading perigynia beneath; bracts setaceous, prolonged, very variable in length and size, usually shorter than the head, often inconspicuous, the upper scale-like; scales ovate, reddish-brown with hyaline margins, the center green, three-nerved, terminating in a rough awn mostly shorter than the perigynia; perigynia plano-convex, membranaceous, typically golden-yellow at maturity, ovate to broadly ovate, usually 2.2–2.7 mm. long, 1.5–1.8 mm. wide, round-tapering at base, short-stipitate, flat, nerveless and sharp-edged to base ventrally, serrulate at base of beak, low convex and nerveless or faintly few-nerved dorsally, not or but scarcely green-margined above, abruptly contracted into the serrulate, dorsally cleft, shallowly bidentate beak, much shorter than the body, the teeth short, appressed, triangular, dull reddish-brown; achenes lenticular, oblong-quadrate, short-stipitate, rounded at base and apex, 1.5 mm. long; style slender, straight, jointed with achene, enlarged at base; stigmas two, slender, rather short, reddish-brown.

TYPE: Paoli, Chester County, Pennsylvania, *Pennell & Long 7598* (P.).

SPECIMENS EXAMINED*

MAINE: York, *Davis* (N.E.); also *Fernald & Long 13017* (N.E., H.); Wells, York County, *Furbish* (N.E.); York Harbor,

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* See footnote on page 351.

Hubbard (N.E.); North Berwick, *Parlin 3, 438* (N.E.); Kittery, York County, *Knowlton* (N.E.); Kittery Point, *Deane* (N.E., H.); Orono, *Fernald & Long 13016* (H.).

NEW HAMPSHIRE: Hampton Falls, *Batchelder* (N.E.); Jefferson, Coos County, *Pease 12689* (N.E.); Portsmouth, *Lunt 228* (N.E.); Seabrook, *Eaton 64* (N.E., H.).

VERMONT: Pownshend, *Wheeler* (N.E.); Middlebury, *Brainerd* (N.E.); also *Eggleston* (N.E.); Berkshire, *Knowlton* (N.E.); Addison, *Hazen 80* (H.); Seabury, *Brainerd* (H.); Lake Drummond, *Brainerd* (H.).

MASSACHUSETTS: Revere, *Forbes* (K.M.); Cambridge, *Tuckerman* (Col., H.); Ipswich, *Oakes* (N.Y.); Andover, *Pease 3086* (N.E.); Manchester, *Hubbard 49* (N.E.); Middlesex Falls, *Rich* (N.E.); West Cambridge, *no collector* (H.); also *Robinson et al.* (N.E.); Weston, *Rich* (N.E.); Brewster, Barnstable County, *Fernald & Long 18120* (N.E.); Middlefield, Hampshire County, *Fernald & Long 9033* (N.E., H.); Stockbridge, Berkshire County, *Hoffman* (N.E.); Springfield, *Andrews* (N.E.).

CONNECTICUT: Oxford, *Harger* (N.E.); Waterbury, *Blewitt 4203* (N.E.); Hartford, *Wright* (N.E.); Southington, *Andrews* (H.); also *Bissell* (H.).

NEW YORK: Selkirk, Albany County, *Peck* (N.Y.); Richmond Valley, Staten Island, *Britton* (Col.); Van Cortlandt, *Bicknell* (Col.); Ithaca, *Wiegand 1834* (H.); Newcomb, Essex County, *House 7404* (H.); Utica (H.).

NEW JERSEY: Princeton Junction, *Mackenzie 4905* (K.M.); Budd's Lake, Morris County, *Mackenzie 3159* (K.M.); Closter, *Austin* (H.).

PENNSYLVANIA: Paoli, Chester County, *Pennell & Long 7598* (P.); Cedar Barrens, Chester County, *Pennell 3909* (P.); Sugartown, Chester County, *Pennell 1374* (P.); also *Pennell & Long 3854, 3867* (P.); Powder Valley, Lehigh County, *Pretz 8218* (P.); Hosensack, Lehigh County, *Pretz 7534* (P.); Lehigh Furnace, Lehigh County, *Pretz 6785* (P.); Preston Run, Delaware County, *Pennell* (P.); Wawa, Delaware County, *Pennell 3647* (P.); Melrose, Montgomery County, *Long* (P.); Telford, Bucks County, *Benner* (P.); Sellersville, Bucks County, *Porter* (P.); Spring Mount, Montgomery County, *Van Pelt* (P.); Revere, Bucks County, *Long* (P.).

DISTRICT OF COLUMBIA: Takoma Park, *Williams* (K.M.).

VIRGINIA: Bluemont, *House 878* (H.).

OHIO: without definite locality, *Sullivant* (Col., H.); Oxford, *Moseley 7253* (H.).

ILLINOIS: Decatur, *Clokey* (K.M., H., N.Y.), Marion County, *Bebb* (H.); Wady Petra, *Chase 71, 366, 1217* (H.); Joliet, *Wheeler & Skeels 283* (H.).

IOWA: Ft. Dodge, *Somes 102* (H.); Peru, *Hollingsworth 392* (H.).

MISSOURI: St. Louis County, *Glatfelter* (K.M.); Butler County, *Bush 2543* (K.M.); Jackson County, *Bush 2013, 2010, 745, 1906, 3941, 6793* (H.), *6779, 6705, 6772, 2024* (K.M.), *1705, 2882* (N.Y.); also *Mackenzie 93, 143, 172* (K.M.).

Further notes on trees and shrubs of the southeastern United States*

W. W. Ashe

Vaccinium carolinianum sp. nov.

A shrub 1–2 m. high, with reddish-brown bark. Ripened twigs, glossy red-brown, glabrous, terete or angular; new shoots puberulous in lines. Leaves, green as they unfold, oblong, obovate or rarely broadly obovate, 3.2–6 cm. long, 1.6–2.8 cm. wide, acute, obtuse or rounded at the apex, narrowed at the base, as they unfold essentially glabrous below, a line of pubescence on the upper surface along the midrib, the margin until mature finely ciliate, entire or on vigorous shoots serrulate above the middle; when mature dark green above and pale and glaucescent beneath. Flowers, appearing from the middle of May to early in June when the leaves are more than half grown, in small glabrous four- to seven-flowered, short, 2-2.5 cm. long racemes, are urceolate, sometimes much contracted at the throat, or short cylindrous, 5–7 mm. long, 4 6 mm. wide (usually nearly as thick as long), cream colored or striped with red or pink; calyx glabrous, lobes broadly triangular. Fruit, ripe in August, 5–7 mm. thick, blue-black with a bloom, sweet.

Pink Beds, Transylvania County, North Carolina, May 27 and July 14, 1916, *W. W. A.* There is also referred here a second specimen from Transylvania County, possibly from the same station, namely, *H. D. House 4195.* This plant differs from *V. atrococcum* (Gray) Heller in being nearly glabrous and in the shape of the corolla; from *V. simulatum* Small in the green color of the unfolding leaves which are prevailingly broader and in the color of the fruit; from *V. pallidum* Ait. in having a much smaller corolla, smaller fruit, prevailingly entire leaves; and from all in the ciliate margin of the foliage.

Castanea Margaretta sp. nov.

Castanea pumila Margaretta Ashe, Bull. Torrey Club **49:** 265. 1922.

The relationship of this plant seems to be with *C. floridana* (Sarg.) Ashe, rather than with *C. pumila* (L.) Mill., but it seems

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* See Bull. Torrey Club **49:** 265–268. 1922.

to be sufficiently different from that species to be treated as a species. *C. pumila* never has small glabrous interior leaves; the pubescence is soft and velvety. The spines on its involucre are usually densely set, straight, and the tips are quite glabrate.

The foliage of *C. floridana* is densely pubescent only at the tips of the shoots and the involucre is sparingly set with canescent spines. Its pubescence is invariably short and close. *C. Margaretta* has the same type of involucre as *C. floridana* and its leaves at the ends of vigorous shoots have much the same kind of very close white pubescence and are often glaucescent. It differs from *C. floridana* in having far longer and stouter aments in its much larger leaves which are relatively broader while the interior leaves are soft pubescent and green beneath or glabrate and glaucescent. In *C. floridana* the pubescent leaves are narrowly lanceolate and the interior and glabrate leaves are prevailingly lanceolate. In *C. Margaretta* the leaves which are white pubescent beneath are lanceolate and the interior leaves are broadly oblanceolate or oblong obovate.

So far as is known *C. floridana* is confined to the immediate coast region of the southeastern states. *C. Margaretta* is confined to the section from north central Alabama (a doubtful specimen from Augusta, Georgia) and northeastern Texas to middle Arkansas.

During the past two years Mr. J. H. Johnson of the Forest Service has furnished material from different parts of Arkansas which seems to show that to the north of the Arkansas River and within the Ozark Mountain region *Castanea Margaretta* is replaced by two other chinquepins, the descriptions of which follow:

Castanea ozarkensis sp. nov.

A tree becoming 12 m. high. Leaves spreading, coarsely serrate, teeth about 5 mm. long, often mucronate; sun leaves lanceolate, 12–20 cm. long, bright green above, closely yellowish or tawny pubescent beneath; shade leaves much broader, sometimes 10 cm. wide, glaucous, glabrous or puberulent beneath. Staminate aments 12–15 cm. long, 7–8 mm. thick. Fruit, in large almost sessile spikes, at times 1.2 dm. long, is 2.7 to 3.2 cm. thick, the densely set spines 1.–1.3 cm. long; nut, oblong-ovate, 1.5 cm. long, dull brown.

Common north of the Arkansas River from Center Ridge, Arkansas, northward to southwestern Missouri and westward to the valley of the White River. Specimens collected in Barry County, Missouri, by Bush and A. B. Smith seem on account of their glaucous leaves to belong to this species rather than to the next, which appears entirely to replace it in northwestern Arkansas in Madison and Washington Counties.

Castanea arkansana sp. nov.

A tree becoming 20 m. high and reaching a diameter of about 1 m. Twigs stout, 3–4 mm. thick, glabrous, ash-gray. Leaves ample, drooping, very coarsely toothed, sometimes doubly serrate, the teeth usually about 1 cm. long including the awn-like tip, which is often recurved; both sun and shade leaves broadly lanceolate or oblong, 13–22 cm. long, 5–8 cm. wide, closely white pubescent beneath. Staminate aments 15–20 cm. long, about 8 mm. thick. Fruit, in stout sessile clusters, often 9 cm. long, and 2.3 cm. thick, densely set with nearly straight spines, 1–1.2 cm. long; the solitary ovate nut dull brown, often 1.7 cm. long, being longer than that of any other American chinquepin.

Carroll, Madison, Franklin, Benton and Washington Counties, Arkansas, the type from near War Eagle Creek, Madison County.

Both of the above proposed species are well separated from other related species by their very large and coarsely toothed foliage and large involucres. The distinguishing characters of *C. arkansana* are its ample drooping foliage, coarsely, often doubly serrate, leaves, the points of the teeth often reflexed and the close white pubescence on the shade leaves.

Celtis laevigata apposita var. nov.

A tree 15 to 20 m. high, with a broad spreading crown, smooth gray branches, and a short trunk, the gray bark on which is more or less muricate. Twigs very slender, puberulent at least when young. Leaves thick and firm, ovate or broadly ovate 4–6.5 cm. long, subcordate or rounded at the unsymmetrical base, acute or acuminate at the apex, nearly or quite glabrous above, rarely slightly roughened, glabrous and pale or glaucescent beneath, entire or nearly so. Fruit globose or subglobose, 4–6 mm. thick, the pedicels somewhat longer than the petioles.

Frequent on rocky, especially limestone, slopes at Camp Knox, Kentucky, *W. W. A.*, July, 1923. In habit and general shape and size of foliage this tree resembles *Celtis georgiana* Small, from which it differs in its larger size and thicker glabrous leaves with entire margins. It is probably best regarded as a thick and broad-leaved form of *Celtis laevigata* Willd., which has developed on these limestone slopes.

Robinia pauciflora sp. nov.

A shrub, propagating extensively by root suckers, with very slender stems 2–4 dm. high, about 2 mm. thick, light dull tan, hispid (on vigorous shoots densely so) with short straw-colored or rarely purplish setae. Stipular spines usually wanting. Leaves slightly bronze as they unfold, sparingly hispid, of seven to eleven (or thirteen) thin, dark green leaflets which are ovate or elliptic and full and rounded at both ends, or rarely broadly ovate and the terminal leaflet suborbicular; peduncles very slender, sparingly hispid, 1.4–3 cm. long, one- to four-flowered; flowers large, 23–25 mm. long, pale bluish-purple with white; calyx barely 1 cm. long, the divisions as long as the tube, their edges ciliate and like the tube with more or less short pubescence mixed with paler larger gland-tipped hairs. Not known to fruit.

This plant is abundant on the mountains immediately across the river from Wolf Creek Post Office, Tennessee, in mixed oak woods, growing with *R. Boyntonii* Ashe, which becomes 2 m. high, and with *R. pedunculata* Ashe, which is also dwarf and which flowers about ten days earlier than *R. pauciflora*. This is one of the plants which has been included with *R. hispida* L., from which it is well separated by its low habit, slender twigs, yellowish setae, and few-flowered racemes.

Robinia albicans sp. nov.

A shrub, propagating extensively by root suckers, with erect wand-like stems 1–1.5 m. high, or in cultivation becoming 2 m. high and much branched. More or less puberulent throughout, especially on the upper surface of the unfolding leaves, or glabrate. Twigs rather stout, 3–5 mm. thick, shining, reddish-tan, stipula-spines short and slender or usually lacking except on vigorous shoots. Leaves greenish-yellow on unfolding, slender, 1.8–2.4 dm. long, of nine to fifteen (or seventeen) pale yellowish-green, wide-spaced leaflets, 3.5–4.5 cm. long, elliptic-oblong or oblong-obovate, full and rounded at base often abruptly pointed at apex, with dark brown puberulent petiolules, racemes slender, 7–11 cm. long, six- to twelve-flowered, peduncle 2 cm. long, flowers 20–22 mm. long, pale lilac-rose with white; calyx green and purplish, 7–8 mm. long including the lower acuminate divisions.

In mixed oak and hickory woods, Transylvania County, North Carolina. This plant has been in cultivation for several years. It has not fruited; nor has any fruit been found upon the wild plants. It was originally included in *R. Boyntonii*, from which, however, it can be separated by its much paler flowers and often obovate leaflets, which are of a pale yellowish-green color.

INDEX TO AMERICAN BOTANICAL LITERATURE

1923

The aim of this Index is to include all current botanical literature written by Americans, published in America, or based upon American material; the word America being used in the broadest sense.

Reviews, and papers that relate exclusively to forestry, agriculture, horticulture, manufactured products of vegetable origin, or laboratory methods are not included, and no attempt is made to index the literature of bacteriology. An occasional exception is made in favor of some paper appearing in an American periodical which is devoted wholly to botany. Reprints are not mentioned unless they differ from the original in some important particular. If users of the Index will call the attention of the editor to errors or omissions, their kindness will be appreciated.

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Allen, R. F. A cytological study of infection of Baart and Kanred wheats by *Puccinia graminis Tritici.* Jour. Agr. Research **23:** 131–152. *pl. 1–6.* 20 Ja 1923.

Andrews, A. L. Two additions to the Bermuda flora. Bryologist **26:** 6. 15 Mr 1923.

Two mosses, *Octoblepharum albidum* (L.) Hedw. and *Bryum murale* Wils.

Andrews, A. L. Additions to the flora of Iceland. Bryologist **26:** 4. 15 Mr 1923.

Andrews, A. L. The status of *Gyroweisia* in North America. Bryologist **25:** 97–100. 2 F 1923.

Andrews, F. M. Abnormal elaters of *Porella platyphylla.* Bull. Torrey Club **50:** 85–87. *pl. 3.* 23 F 1923.

Bakke, A. L., & Erdman, L. W. A comparative study of sand and solution cultures of Marquis wheat. Am. Jour. Bot. **10:** 18–31. *f. 1.* 3 F 1923.

Bartholomew, E. T., Barrett, J. T., & Fawcett, H. S. Internal decline of lemons I. Am. Jour. Bot. **10:** 67–70. *pl. 7.* 2 Mr 1923.

Berry, E. W. The Mayence basin, a chapter of geologic history. Sci. Mo. **16:** 113–129. *f. 1–7.* F 1923.

Blake, S. F. Two new genera related to *Narvalina.* Jour. Washington Acad. Sci. **13:** 102–107. 19 Mr 1923.

Eriocentrodea and *Cyathomone*, genera of Carduaceae from Ecuador and Peru.

Brandes, E. W. Mechanics of inoculation with sugar-cane mosaic by insect vectors. Jour. Agr. Research **23:** 279–284. *pl. 1, 2.* 27 Ja 1923.

Britton, N. L. Studies of West Indian plants. Bull. Torrey Club **50:** 35–56. 7 F 1923.

Includes 69 new species in many families.

Brown, E. D. W. Apogamy in *Phegopteris polypodioides.* Bull. Torrey Club **50:** 17–34. *f. 1–20.* 7 F 1923.

Brown, N. A. Bacterial leafspot of *Geranium* in the United States. Jour. Agr. Research **23:** 361–372. 3 F 1923.

Bryan, O. C. Effect of acid soils on nodule-forming bacteria. Soil Sci. **15:** 37–40. Ja 1923.

Bryan, O. C. Effect of reaction on growth, nodule formation, and calcium content of alfalfa, alsike clover and red clover. Soil Sci. **15:** 23–30. *pl. 1–3.* Ja 1923.

Burkholder, W. H. Bean disease in New York. Cornell Extens. Bull. 58: 3–25. *f. 1–13.* F 1923.

Campbell, D. H. Australasian botanical notes I. Queensland and New South Wales. Am. Jour. Bot. **10:** 38–56. *f. 1–5.* 3 F 1923.

Chardon, C. E., & Veve, R. A. The transmission of sugar-cane mosaic by *Aphis Maidis* under field conditions in Porto Rico. Phytopathology **13:** 24–29. Ja 1923.

Cook, M. T. The origin and structure of plant galls. Science II. **57:** 6–14. 5 Ja 1913.

Dickson, F., & Fisher, W. R. A method of photographing spore discharge from apothecia. Phytopathology **13:** 30–32. *f. 1, 2.* Ja 1923.

Elliott, J. A. Cotton-wilt, a seed-borne disease. Jour. Agr. Research **23:** 387–395. *pl. 1, 2.* 3 F 1923.

Evans, A. W. Corsiniaceae. N. Amer. Flora **14:** 29, 30. 19 Ja 1923.

Evans, A. W. Marchantiaceae. N. Amer. Flora **14:** 57–66. 19 Ja 1923.

Evans, A. W. Marchantiales. N. Amer. Flora **14:** 9, 10. 19 Ja 1923.

Evans, A. W. Rebouliaceae. N. Amer. Flora **14:** 39–56. 19 Ja 1923.

Evans, A. W. Sauteriaceae. N. Amer. Flora **14:** 35–37. 19 Ja 1923.

Evans, A. W. Targionaceae. N. Amer. Flora **14:** 31–34. 19 Ja 1923.

Farwell, O. A. *Corallorhiza maculata* Raf. Rhodora **25:** 31, 32. 27 F 1923.

Fenneman, N. M. Recent work in paleobotany. Science II. **57:** 44, 45. 12 Ja 1923.

Fernald, M. L. The native tansy of Newfoundland. Rhodora **25:** 13–16. 24 Ja 1923.

Fernald, M. L. The southern variety of *Thelypteris fragrans.* Rhodora **25:** 1–4. 24 Ja 1923.

Fernald, M. L. *Vaccinium uliginosum* and its var. *alpinum.* Rhodora **25:** 23–25. 27 F 1923.

Fitzpatrick, H. M. Monograph of the Nitschkieae. Mycologia **15:** 23–44. *pl. 1–7.* 25 Ja 1923.

Includes one new species.

Gager, C. S. A proposal for wild plant conservation. Science II. **57:** 52–54. 12 Ja 1923.

Gaines, E. F. Genetics of bunt resistance in wheat. Jour. Agr. Research **23:** 445–480. *pl. 1–3.* 10 F 1923.

Gates, F. C. Influence of moonlight on movements of leguminous leaflets. Ecology **4:** 37–39. 21 F 1923.

Gericke, W. F. Further notes on the growing of wheat in one-salt solutions. Soil Sci. **15:** 69–74. F 1923.

Giardini, G. I. A preliminary report on the lichens of western Pennsylvania. Bryologist **25:** 100–108. 2 F 1923.

Gleason, H. A. A rare plant re-discovered. Jour. New York Bot. Gard. **24:** 43, 44. F 1923.

Lissocarpus Benthami from Guiana.

Gress, E. M. *Falcaria Rivini*, a plant new to the United States. Rhodora **25:** 12, 13. 24 Ja 1923.

Harlan, H. V., & Pope, M. N. Water content of barley kernels during growth and maturation. Jour. Agr. Research **23:** 333–360. *f. 1–15.* 3 F 1923.

Harrington, G. T. Use of alternating temperatures in the germination of seeds. Jour. Agr. Research **23:** 295–332. *f. 1–20.* 3 F 1923.

Harrington, G. T., & Crocker, W. Structure, physical characteristics, and composition of the pericarp and integument of Johnson grass seed in relation to its physiology. Jour. Agr. Research **23:** 193–222. *f. 1–10.* 20 Ja 1923.

Harrington, G. T., & Hite, B. C. After-ripening and germination of apple seeds. Jour. Agr. Research **23:** 153–161. 20 Ja 1923.

Hastings, G. T. An intensive local study in Rhode Island. Torreya **23:** 9, 10. F 1923.

Haynes, C. C., & Howe, M. A. Riellaceae. N. Amer. Flora **14:** 7, 8. 19 Ja 1923.

Haynes, C. C., & Howe, M. A. Sphaerocarpaceae. N. Amer. Flora **14:** 3–6. 19 Ja 1923.

Haynes, C. C., & Howe, M. A. Sphaerocarpales. N. Amer. Flora **14:** 2. 19 Ja 1923.

Herre, A. W. C. T. Lichens, impossible plants. Sci. Mo. **16:** 130–140. F 1923.

Howe, M. A. Ricciaceae. N. Amer. Flora **14:** 11–28. 19 Ja 1923.

Hurd, A. M. Hydrogen-ion concentration and varietal resistance of wheat to stemrust and other diseases. Jour. Agr. Research **23**: 373–386. 3 F 1923.

Johnson, J. A bacterial leafspot of tobacco. Jour. Agr. Research **23**: 481–494. *pl. 1–4.* 10 F 1923.

Kidder, N. T. Isle au Haut [Maine] plants. Rhodora **25**: 16. 24 Ja 1923.

King, C. J. Cotton rootrot in Arizona. Jour. Agr. Research **23**: 525–527. 17 F 1923.

Larsen, J. A. Association of trees, shrubs, and other vegetation in the northern Idaho forests. Ecology **4**: 63–67. 21 F 1923

[**Lemay, P.**] Flore du Labrador. Nat. Canad. **49**: 183–186. F 1923.

A list of plants collected in Labrador before 1895.

Lipman, J. G. Tendencies in agricultural research. Science II **57**: 71–76. 19 Ja 1923.

Lipman, J. G., & Waksman, S. A. The oxidation of selenium by a new group of autotrophic micro-organisms. Science II **57**: 60. 12 Ja 1923.

Löhnis, F., & Smith, N. R. Studies upon the life cycles of the bacteria—II. Life history of *Azotobacter.* Jour. Agr. Research **23**: 401–432. *pl. 1–9.* 10 F 1923.

Mackenzie, K. K. Notes on *Carex*—XII. Bull. Torrey Club **49**: 361–373. 27 Ja 1923.

Includes 3 new species from eastern North America.

Manns, T. F., & Adam, J. F. Parasitic fungi internal of seed corn. Jour. Agr. Research **23**: 495–524. *pl. 1–13.* 17 F 1923.

McHargue, J. S. Iron and manganese content of certain species of seeds. Jour. Agr. Research **23**: 395–400. 10 F 1923.

Mitra, M. Diseases of *Zea Mays* and *Sorghum vulgare* caused by species of *Helminthosporium.* Mem. Dept. Agr. India **19**: 219–242. *pl. 1–3.* F 1923.

Munz, P. A., & Johnston, I. M. Miscellaneous notes on plants of southern California—II. Bull. Torrey Club **49**: 349–359. 27 Ja 1923.

Includes new species in *Sphaeralcea* (1), *Phlox* (1), and *Galium* (1).

Murrill, W. A. Dark-spored agarics. V. *Psilocybe*. Mycologia **15**: 1–22. 25 Ja 1923.

Includes 8 new species.

Nelson, J. C. Notes on the ballast-vegetation at Linnton, Oregon. Torreya **23**: 1–3. F 1923.

Oldenbusch, C. Stimulation of plants by carbon disulphide. Bull. Torrey Club **49**: 375–389. 27 Ja 1923.

Osterhout, G. E. What is *Geranium caespitosum* James? Bull. Torrey Club **50**: 81–84. 23 F 1923.

Rhoads, A. S. The formation and pathological anatomy of frost rings in conifers injured by late frosts. U. S. Dept. Agr. Bull. 1131: 1–16. *pl. 1–6.* 13 F 1923.

Schaffner, J. H. Sex reversal in the Japanese hop. Bull. Torrey Club **50**: 73–79. *pl. 2.* 23 F 1923.

Schultz, E. S., & Folsom, D. A "spindling-tuber disease" of Irish potatoes. Science II **57**: 149. 2 F 1923.

Seifriz, W. The gregarious flowering of the orchid *Dendrobium crumenatum*. Am. Jour. Bot. **10**: 32–37. 3 F 1923.

Shapovalov, M. Relation of potato skinspot to powdery scab. Jour. Agr. Research **23**: 285–294. *pl. 1–4 + f. 1.* 27 Ja 1923.

Shaw, W. R. *Merrillosphaera africana* at Manila. Philipp. Jour. Sci. **22**: 185–218. *pl. 1–7.* F 1923.

Skinner, J. J., & Allison, F. E. Influence of fertilizers containing borax on the growth and fruiting of cotton. Jour. Agr. Research **23**: 433–444. *pl. 1–4.* 10 F 1923.

Smith, E. L. The histology of certain orchids with reference to mucilage secretion and crystal formation. Bull. Torrey Club **50**: 1–16. *pl. 1.* 7 F 1923.

Spoehr, H. A., & McGee, J. M. Studies in plant respiration and photosynthesis. Carnegie Instit. Washington Publ. 325: i–iv + 1–98. *f. 1–27.* F 1923.

Sprague, T. A. Notes on Theaceae. Jour. Bot. **61:** 17–19. Ja 1923.

Sprague, T. A. Types of Linnean species. Jour Bot. **61:** 26, 27. Ja 1923.

Stakman, L. J. Some fungi causing root and foot rots of cereals. Univ. Minnesota Stud. Biol. Sci. **4:** 139–162. *pl. 26–28 + f. 1.* Ja 1923.

Stapf, O. *Echinocactus undulatus.* Bot. Mag. **148:** *pl. 8951.* 20 F 1923.

[Stapf, O.] *Maxillaria Fletcheriana.* Bot. Mag. **148:** *pl. 8949.* 20 F 1923.

Stomps, T. J. Über die Umwandlung des Blattes zum Stengel. Ber. Deuts. Bot. Ges. **41:** 4–11. 22 F 1923.

Suessenguth, K. Über die Pseudogamie bei *Zygopetalum Mackayi* Hook. Ber. Deuts. Bot. Ges. **41:** 16–23. *f. 1.* 22 F 1923.

Swingle, W. T., & Robinson, T. R. Two important new types of citrous hybrids for the home garden—citrangequats and limequats. Jour. Agr. Research **23:** 229–239. *pl. 1–4.* 27 Ja 1923.

Tabor, R. J., & Bunting, R. H. On a disease of cocoa and coffee fruits caused by a fungus hitherto undescribed. Ann. Bot. **37:** 153–157. *f. 1–3.* Ja 1923.

Trachysphaera, gen. nov.

Tanaka, T. *Citrus* fruits of Japan. Jour. Hered. **13:** 243–253. *f. 1, 2.* 15 F 1923.

Thayer, P. A variation in the Downing gooseberry. Jour. Hered. **13:** 284. 15 F 1923.

Thomas, W. Ultimate analysis of the mineral constituents of a Hagerstown silty clay loam soil and occurrence in plants of some of the elements found. Soil Sci. **15:** 1–18. Ja 1923.

Ulbrich, E. Ranunculaceae novae vel critacae. VI. Ranunculaceae peruvianae novae. Notizbl. Bot. Gart. und Mus. Berlin-Dahlem **8:** 325–327. 1 F 1923.

New species in *Clematis* (2) and *Ranunculus* (1).

Uruena, J. G. Teigne tonsurante trichophytique a culture crateriforme. Rev. Mexicana Biol. **3:** 93–119. *pl. 1, 2 + f. 1–13.* F 1923.

Ver Hulst, J. H., Peterson, W. H., & Fred, E. B. Distribution of pentosane in the corn plant at various stages of growth. Jour. Agr. Research **23:** 655–663. 24 F 1923.

Weatherby, C. A. Some critical plants of Atlantic North America. Rhodora **25:** 17–23. 27 F 1923.

Includes *Chelone Grimesii*, sp. nov., from Virginia.

Weber, G. F. *Septoria* disease of rye, barley and certain grasses. Phytopathology **13:** 1–23. *f. 1–9.* Ja 1923.

Weston, W. H. Production and dispersal of conidia in the Philippine sclerosporas of maize. Jour. Agr. Research **23:** 239–278. *pl. 1–10 + f. 1, 2.* 27 Ja 1923.

Wetmore, R. H. Plants of the Hamilton Inlet and Lake Melville region, Labrador. Rhodora **25:** 4–12. 24 Ja 1923.

Wilson, E. H. The rhododendrons of northeastern Asia exclusive of those belonging to the subgenus *Anthodendron.* Jour. Arnold Arb. **4:** 33–55. 16 F 1923.

Wilson, J. K. The nature and reaction of water from hydathodes. Cornell Univ. Agr. Exp. Sta. Mem. **65:** 3–11. F 1923.

Wright, R. C., & Taylor, G. F. The freezing temperatures of some fruits, vegetables and cut flowers. U. S. Dept. Agr. Dept. Bull. 1133: 1–8. 28 F 1923.

Yuncker, T. G. Revision of the South American species of *Cuscuta.* Am. Jour. Bot. **10:** 1–17. *pl. 1–5.* 3 F 1923.

Includes 1 new species.

Zinn, J. Correlations between various characters of wheat and flour as determined from published data from chemical milling, and baking tests of a number of American wheats. Jour. Agr. Research **23:** 529–548. 17 F 1923.

Vol. 50 No. 12

BULLETIN

OF THE

TORREY BOTANICAL CLUB

DECEMBER, 1923

Studies in the genus Lupinus—IX. Lupinus bicolor

CHARLES PIPER SMITH

(WITH SEVEN TEXT FIGURES)

This species, like *L. nanus*, the subject of my last paper (Bull. Torrey Club **50:** 159. 1923), is so abundant, variable, and widely distributed that its consideration absorbs all the space available at this time. The next paper, however, will complete my treatment of the *Micranthi*, including a key to the species recognized. Of these the following is the sixth species in the linear arrangement adopted.

6a. LUPINUS BICOLOR Lindl. Bot. Reg. **13:** *pl. 1109.* 1827. [FIG. 85.]

Lupinus micranthus bicolor Wats. Proc. Am. Acad. **8:** 536. 1873.

Lupinus sabulosus Heller, Muhlenbergia **7:** 9. 1911.

Lupinus strigulosus Gandoger, Bull. Soc. Bot. France **60:** 461. 1913.

Annual, fibrous, erect and simple, or diffusely branched at the base, 8–40 cm. tall, usually villous; leaves few or many, pubescent on both sides; petioles 3–7 cm. long; stipules subulate, 5–10 mm. long; leaflets five to seven, oblanceolate or cuneate, acute or obtuse, 10–20 mm. long by 2–5 mm. wide; peduncles 3–7 cm. long, racemes 1–7 cm. long, verticils one to three; flowers 8–12 mm. whorled, scattered, or umbellate by reduction of the raceme; bracts subulate, deciduous, pedicels slender, 1–3 mm. long; calyx minutely bracteolate or ebracteolate, upper-lip bifid, 2–4 mm. long, lower-lip minutely three-toothed or entire, 4–6 mm. long; petals blue and white, banner about 8 mm. long by 6–8 mm. wide, obovate, elliptic, rhombic, to orbicular-obovate, angled to emarginate, the purple-dotted white center changing to violet, the sides much reflexed, wings oblong to elliptical, 6–8 by 4–5 mm., keel slender, acute, arcuate or nearly

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[The BULLETIN for November (**50:** 343–372) was issued December 1, 1923.]

straight, the slender acumen well defined, ciliate above between middle and apex; pods 15–20 mm. long by 3–5 mm. wide, appressed-hairy, ovules five to eight; seeds rhombic or elliptic-oblong, 2–3 mm. long by about 1.5 mm. wide, pale flesh-color, pearly-white, or grayish, unmarked or dotted or mottled with gray or brown, with or without an oblique lateral line.

Heller's recent review of this species (Muhlenbergia **7**: 6. 1911) permits me to omit here quotations from the original description and detailed references to the older literature. I can easily accept his conception, as to the typical form of the species, but I cannot follow his idea as to its limitations. Since my former published reference to this species (Muhlenbergia **6**: 137. 1911), I have had much more experience with it both in the field and the herbarium, and now see it as another of those species which consist of a large number of mutating or intergrading forms which almost defy classification. As in *L. sparsiflorus*, *L. concinnus*, and *L. nanus*, the wide variation in the shape of the leaflets in *L. bicolor* has much tempted me to recognize several varieties additional to those distinguished below; but here, especially, the inconstancies evident have led me to trim the list to just seven forms.

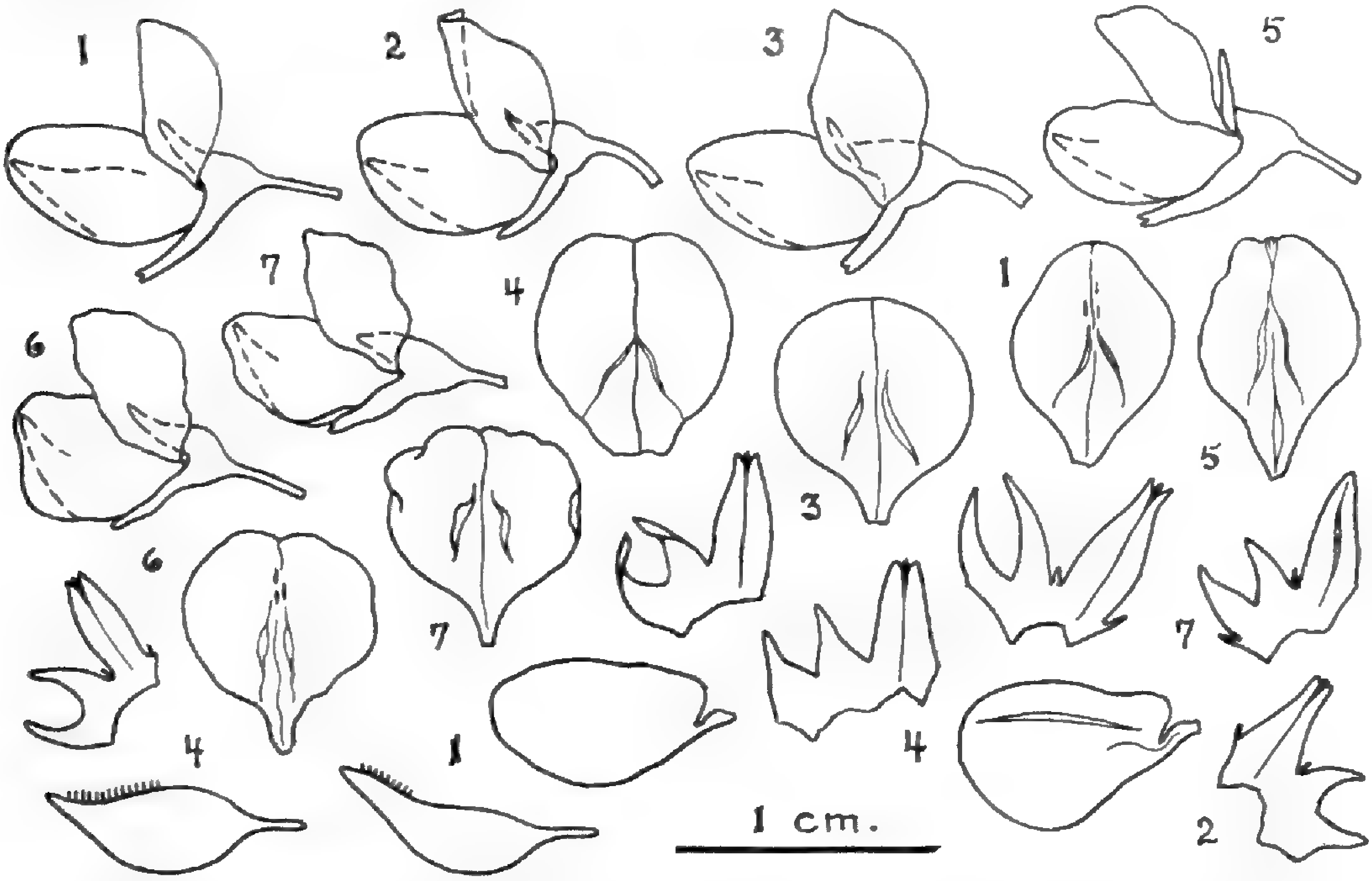

FIG. 85. LUPINUS BICOLOR Lindl. 1. *A. A. Heller 10069*, Vancouver, Wn. (CPS); 2. *J. Macoun 78892*, Vancouver Island (B); 3. *F. X. Williams*, San Francisco (CPS); 4. *C. F. Baker 816*, San Mateo County (UC); 5. *A. Eastwood 1*, Santa Barbara County (CPS); 6. *A. A. Heller 11227*, Butte County (CA); 7. *W. N. Suksdorf 5928*, Bingen, Wn. (CPS).

I have much desired to allow *L. sabulosus* varietal rank, but the differentiating characters well shown by Heller's drawings do not check up geographically. According to his drawings, his *10244*, from San Francisco, distributed as *L. sabulosus*, must be called *L. bicolor*, while several specimens from northern California and Vancouver Island should be referred to *L. sabulosus*. In truth, variation in the shape of the banner and in the size and color of the seeds, as well as in the size and shape of the leaflets, is rife in this species. Also the blue pigment is often missing from the petals, giving pink or white flowers.

L. strigulosus Gandoger is another extreme that, in itself, is perhaps possible of differentiation; but intermediates are numerous and make their classification a hair-splitting process.

Specimens assigned to the species, *sensu stricto*, are:—

BRITISH COLUMBIA. Vancouver Island: Colwood, July, 1922, *C. F. Newcombe & C. P. Smith 3675* (CPS); Esquimalt, May, 1908, *J. Macoun 78891* (B); same, May, 1914, *J. K. Henry* (CA); Oak Bay, May, 1908, *J. Macoun 78889, 78892*, and *78893* (B); Victoria, May, 1901, *A. J. Pineo* (BP, UC); same, May, 1914 and 1915, *J. K. Henry* (CA); same, Beacon Hill, May, 1908, *J. Macoun 78890* (B); same, May, 1911, *C. F. Newcombe* (CPS); same, Clover Point, May, 1915, *C. F. Newcombe* (CPS); same, Oak Park, June, 1920, *A. Eastwood 9742* (CA); same, Thetis Lake, June, 1919, *C. F. Newcombe* (CPS).

WASHINGTON. Clarke County: Vancouver, May, 1910, *A. A. Heller 10069* (B, DS, UC, CPS). Island County: Whidbey Island, *N. L. Gardner* (UC). Klickitat County: Bingen, April and May, 1907, *W. N. Suksdorf 5928* (CPS); same, April and June, 1911, *W. N. Suksdorf 7204* (B, UC, CPS). Pierce County: Tacoma prairies, May, 1908, *J. B. Flett* (UC). San Juan County: Argyle hills, July, 1919, *Lucile Roush* (DS); Argyle, June and Aug., 1917, *S. M. & E. B. Zeller 923* (B).

OREGON. Coos County: Marshfield, July, 1911, *W. Hayden* (CA); same, June, 1914, *W. Hayden* (CPS). Marion County: Salem, May, 1911, *M. E. Peck 2265* (CPS); same, July, 1922, *C. P. Smith 3578* and *3585* (CPS). Wasco County: The Dalles, May, 1882, *T. Howell* (DS); same, April, 1902, *E. P. Sheldon 9154* (DS); same, May, 1906, *J. Lunell* (DS).

CALIFORNIA. Alameda County: Oakland hills, May, 1888, *E. L. Greene* (DS); same, Sky Line Boulevard, May, 1922, *C.*

P. Smith 3535 (CPS). Amador County: New York Falls, April, 1893, *G. Hansen 15* (DS); same, June, 1893, *G. Hansen 954* (DS). Butte County: Centerville, April, 1915, *A. A. Heller 11857* (B, CA, DS, UCX); Big Chico canyon, March, 1914, *A. A. Heller 11227* (CA, UCX); Chico, April, 1903, *E. B. Copeland*, Baker distribution 3032 (BP); Mud Creek canyon, April, 1919, *A. A. Heller 13109* (CA, UCX); Rock Creek hills, April, 1915, *A. A. Heller 11817* (CA, DS, UCX, US). Contra Costa County: near Moraga Valley, May, 1888, *E. L. Greene* (UC). Glenn County: Stony Creek, Orland, May, 1915, *A. A. Heller 11887* (DS, UCX). Humboldt County; Bucksport, June, 1900, *J. P. Tracy 838* (UC); same, May, 1911, *J. P. Tracy 3195* (DS); Hoopa Indian Reservation, June, 1901, *H. P. Chandler 1314* (UC). Marin County; Mill Valley, May, 1913, *K. Brandegee* (UC); Mount Tamalpais, April, 1922, *L. R. Abrams 8069* (DS, CPS); near Tennessee Bay, May, 1896, *A. Eastwood* (UC). Mendocino County: Fort Bragg, July, 1920, *C. D. Duncan 212* (DS); Ukiah, June, 1913, *A. Eastwood* (CA). Placer County: Newcastle, May, 1884, *M. K. Curran* (CA). Sacramento County: Folsom, April, 1883, *T. S. Brandegee* (CA). San Francisco County: Childrens' Hospital, April, 1911, *A. A. Heller 10244* (B, BP, DS, UCX, CPS); Forest Hill, April, 1914, *P. B. Kennedy 4644* (UCX); Marine Hospital, April, 1903, *A. A. Heller 6627* (B, BP, DS, UC); sand hills, May, 1903, *C. F. Baker 2837* (B, BP, UC); also some sixteen other collections. San Luis Obispo County: San Simeon, June, 1888, *M. K. Curran* (CA). San Mateo County: Coast Range summit, May, 1902, *C. F. Baker 816* (B, BP, CA, US); Montara Mountains, above Lake Pilarcitos, June, 1922, *C. P. Smith 3557* (CPS); San Bruno hills, April, 1903, *C. F. Baker 1888* (BP, CA, UC); also seven other collections. Santa Barbara County: Ellwood, May, 1908, *A. Eastwood 1* (CA, CPS); Rincon ranch, May, 1908, *A. Eastwood* (CA, CPS). Siskiyou County: Yreka, April, 1910, *G. D. Butler 1190* and *1252* (DS). Stanislaus County: Oakdale, April, 1922, *C. P. Smith 3476* (CPS). Sutter County: Sutter City, March, 1905, *A. A. Heller 7568* (B, DS, UC). Tuolumne County: near French Flat, April, 1919, *R. S. Ferris 1535* (CA, DS). Yolo County: Knights Landing, April, 1892, *F. P. Nutting* (UC).

Key to the varieties of Lupinus bicolor *

Keel non-ciliate, or with one to four stray cilia; flowers 5–8 mm. long.	*6d.* var. *Pipersmithii.*
Keel distinctly ciliate on upper edges, between middle and apex.	
Lower calyx-lip trifid; flowers 5–8 mm. long.	*6g.* var. *trifidus.*
Lower calyx-lip tridentate or subentire.	
Flowers 8–12 mm. long.	*6a.* *L. bicolor.*
Flowers 4–8 mm. long.	
Flowers 6–8 mm. long.	
Racemes reduced to one verticil, or with more or less of two.	*6b.* var. *umbellatus.*
Racemes of three to six, or more, verticils.	*6c.* var. *tridentatus.*
Flowers 4–6 mm. long.	
Pods five- to eight-seeded.	*6e.* var. *microphyllus.*
Pods four- or five-seeded.	*6f.* var. *tetraspermus.*

6b. **Lupinus bicolor umbellatus** (Greene) comb. nov. [FIG. 86.]

Lupinus umbellatus Greene, Bull. Cal. Acad. **2:** 145. 1886.

Differing only in the reduction in the racemes and flowers, the former usually reduced to one verticil, the latter in size to about 7 mm. long. Most, if not all, of the mainland collections referred here by the collectors I have considered it better to refer to other varieties of the species.

FIG. 86. LUPINUS BICOLOR UMBELLATUS (Greene) C. P. Smith. *T. S. Brandegee*, Santa Cruz Island (UC).

CALIFORNIA. Santa Barbara County: Santa Cruz Island, July and Aug., 1886, *E. L. Greene* (UC); same, April, 1888, *T. S. Brandegee* (UC); same, May, 1908, *Frida Niedermüller* (UC): same, 1919, *Mrs. A. Swain* (CA).

6c. **Lupinus bicolor tridentatus** Eastwood, var. nov. [FIG. 87.]

A planta typica differt floribus minoribus 6–8 mm. longis, labio inferiore calycis tridentato, vexillo elliptico ad obovato vel late spatulato, carina ciliata.

Differing from typical *L. bicolor* in the reduced size of the flowers, which are from 6–8 mm. long, in from three to six or more distinct verticils, the lower calyx-lip distinctly three-toothed. Greatly varying in stature, more commonly 15–25 cm. tall, but sometimes lower and again as much as 40 cm. tall.

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* In following this key, use the minimum measurements for dried flowers only and the maximum measurements for fresh flowers only.

Abundant in the Coast Ranges of western Middle California, and apparently local, at scattered stations, elsewhere.

BRITISH COLUMBIA. Vancouver Island: Colwood, July, 1922, *F. C. Newcombe & C. P. Smith 3674* and *3676* (CPS).

WASHINGTON. Clarke County: Vancouver Lake, July, 1922, *C. P. Smith 3589* (CPS).

OREGON. Jackson County: Central Point, July, 1918, *A. A. Heller 13077* (DS, UCX). Linn County: Albany, May, 1922, *M. W. Gorman 5729* (CPS).

CALIFORNIA. Alameda County: Alameda, May, 1891, *E. L. Greene* (DS 36730); Oakland, March, 1864, *W. H. Brewer 2773* (CA, UC); between Mission San Jose and Livermore, April, 1904, *A. A. Heller 7314* (B, DS, UC, UCX); Sunol Valley, June, 1916, *L. R. Abrams 5698* (DS, CPS). Amador County: no locality, 1891, *G. Hansen* (UC); Ione, March, 1921, *A. Eastwood 10089* (CA). Contra Costa County: Antioch, April, 1922, *C. P. Smith 3492* (CPS); Mount Diablo, May, 1862, *W. H. Brewer 1149* (UC); Point Richmond, March, 1900, *J. P. Tracy 624* (UC). Eldorado County: Clarksville to Shingle Springs, April, 1911, *A. A. Heller 12285* (CA, DS, UCX). Humboldt County: Humboldt Bay, May, 1901, *H. P. Chandler 1146* (DS, UC); Trinidad Head, 1889, *W. R. Dudley* (DS); Van Duzan Valley, June–July, 1908, *J. P. Tracy 2693* (UC); Willow Creek, June, 1910, *L. R. Abrams 7172* (DS). Kern County: Tehachapi, May, 1905, *A. A. Heller 7836* (B, DS); same, *K. Brandegee* (CA, UC). Los Angeles County: Antelope, May, 1895, *A. Davidson* (UC); Antelope Valley foothills, May, 1902, *H. M. Hall 3053* (UC); near Los Angeles, June, 1904, *pupils of Los Angeles High School* (UC); Sierra Madre, June, 1914, *C. P. Smith 2880* (CPS).

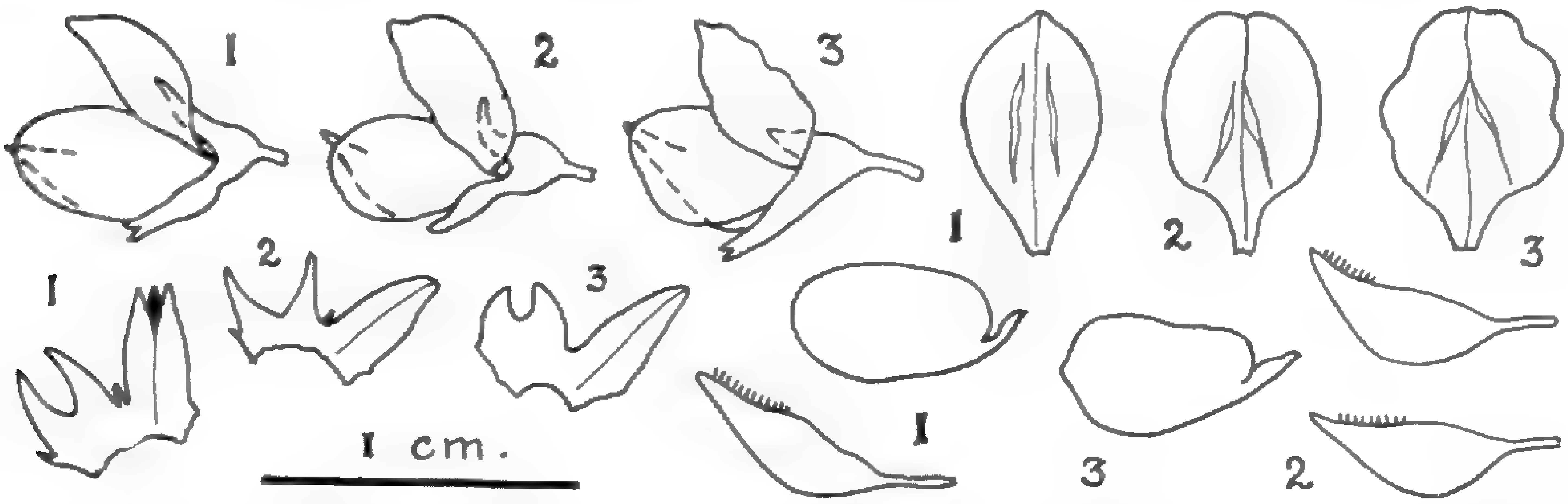


FIG. 87. LUPINUS BICOLOR TRIDENTATUS A. Eastwood. 1. *C. P. Smith 1422a*, San Mateo County (CPS); 2. *A. A. Heller 7836*, Kern County (UC); 3. *A. A. Heller 13077*, Oregon (CA).

Marin County: Mount Tamalpais, April, 1899, *A. Eastwood* (CA); Point Reyes Station, May, 1921, *C. P. Smith 3378* and *3379* (CPS); Ross Valley, April, 1892, *F. T. Bioletti* (UC). Mariposa County: Cathey Valley, April, 1915, *A. Eastwood 4351* (CA); Yosemite Valley, June, 1906, *Anna Head* (CA); same, June, 1911, *H. M. Hall 8871* (UC). Mendocino County: Russian River, Ukiah Valley, April, 1918, *L. R. Abrams 6976* and *6977* (DS, CPS); Wolf Creek, July, 1916, *L. R. Abrams 5862* (DS). Monterey County: Los Pesares, Santa Lucia Mountains, May, 1920, *L. R. Abrams 7354* (DS); Santa Lucia Mountains, June, 1901, *W. R. Dudley* (DS). Napa County: Calistoga, April, 1903, *C. F. Baker 1982* (BP). Orange County: Orange, April, 1902, *J. B. Davy* (UC). Placer County: Roseville, April, 1883, *T. S. Brandegee* (CA). Sacramento County: Fair Oaks, March, 1900, *M. S. Baker* (UC); Folsom, April, 1916, *A. A. Heller 12307* (CA, UCX). San Benito County: San Juan hill, May, 1922, *C. P. Smith 3514* (CPS). San Diego County: Cuyamaca Lake, June, 1903, *L. R. Abrams 3841* (DS); Descanso, May, 1906, *T. S. Brandegee* (B, UC); Ramona, April, 1903, *H. M. Hall 3866* (UC); Warners Springs, 1911, *Mrs. A. L. Coombs* (CA); Witch Creek, *R. D. Alderson*, plant III (UC). San Francisco County: Lake Merced, April, 1893, *W. R. Dudley* (DS). San Luis Obispo County: Arroyo Grande, May, 1895, *M. Alice King* (UC); Avila, *Mrs. R. W. Summers* (UC 55703, plant II). San Mateo County: near Colma, April, 1908, *C. P. Smith 1422a* (DS, CPS); Cooleys Landing, April, 1922, *E. A. McGregor* (CPS); Crystal Springs Lake, April, 1904, *L. R. Abrams* (DS, CPS); Lake San Andreas, April, 1903, *C. F. Baker 1921* (BP, UC). Santa Barbara County: Santa Barbara, May, 1918, *J. C. Carlson* (CA). Santa Clara County: Betabel, April, 1921, *C. P. Smith 3267* and *3268* (CPS); Black Mountain, May, 1903, *A. D. E. Elmer 4797* (BP, CA, DS, UC); Evergreen foothills, *J. B. Davy 95 A* (UC); Loma Prieta, April, 1894, *J. B. Davy 527*, *531*, and *635* (UC); Palo Alto, May, 1893 *I. Tidestrom* (UC); San Martin, March, 1901, *H. P. Chandler 909* (BP); Smith Creek Hotel, June, 1908, *C. P. Smith 1464* (DS, CPS); Wright, April, 1921, *C. P. Smith 3313* and *3314* (CPS); also about twenty-five other collections. Santa Cruz County: Capitola, April, 1903, *C. F. Baker 1963* (B, BP, UC); Glenwood, Sept., 1907, *H. Davis* (CPS); Santa Cruz, April, 1903, *A. A. Heller 6554* (B, BP, DS, UC, UCX)

Tuxedo, April, 1904, *W. R. Dudley* (DS). Shasta County: Anderson, April, 1918, *A. A. Heller 12991* (CA); Redding, 7 miles south, April, 1917, *A. A. Heller 12992* (CA). Sonoma County: Santa Rosa, April, 1921, *A. Eastwood 10369* (CA, TYPE). Sutter County: Marysville Buttes, May, 1914, *A. A. Heller* (DS); same, April, 1914, *A. A. Heller 11255* (CA, UCX); same, March, 1905, *A. A. Heller 7574* (B, UC, CPS). Tuolumne County: Bear Creek, April, 1896, *C. A. Purpus 1726* (UC); Grape Vine Spring, March, 1898, *P. S. Woolsey* (UC, 126973, II); Kaweah, April, 1903, *R. Hopping 550* (UC).

6d. **Lupinus bicolor Pipersmithii** (Heller) comb. nov. [FIG. 88.]

Lupinus Pipersmithii Heller, Muhlenbergia **7:** 93. *f. 16–17.* 1911.

Differing from typical *L. bicolor* in reduction of size of flowers which are from 5–8 mm. long, and in the non-ciliate keel. The seeds are usually pale flesh-colored, more or less mottled with yellowish-brown.

When I first found this interesting variation, I really considered it to be a worthy species (Muhlenbergia **6:** 139–141. 1911), in comparison with its relatives then known to me; but now, after much more extensive experience with it and *L. bicolor*, I must classify it where my judgment says it belongs. Except for the lack of keel-ciliation, it can not be distinguished from var. *tridentatus* at Antioch, Betabel, and San Juan, nor from var. *microphyllus* at many points in the San Joaquin Valley. It is the dominant form of *L. bicolor* in the last locality and seems to be local and less common elsewhere. Since Heller's description is readily available it is not reproduced here.

CALIFORNIA. Amador County: Ione, March, 1921, *A. Eastwood 10079* (CA). Contra Costa County: Antioch, April, 1889, *Chestnut & Drew* (UC); same, April, 1903, *C. F. Baker 2822* (BP, CA, UC); same, April, 1921, *A. Eastwood 10280* and *10306* (CA); same, April, 1922, *C. P. Smith 3482* (CPS); Brentwood, May, 1893, *A. Eastwood* (CA); Byron Springs, March, 1914, *A. Eastwood 3784* (CA). Fresno County: Big Sandy Creek, April, 1915, *Julia McDonald* (CA); Clovis, April, 1902, *C. H. Thompson* (DS, CPS); Pollasky, April, 1906, *A. A. Heller 8154* (B, CA, DS). Glenn County: Orland, Stony Creek, May, 1915, *A. A. Heller 11886* (CA, DS, UCX). Madera

County; Madera, April–May, 1896, *J. B. Davy 1698* (UC); same, April, 1897, *W. A. Setchell* (UC). Mariposa County: Blochman ranch, April, 1915, *A. Eastwood 4253* (CA). Merced County: Merced, April, 1915, *A. Eastwood 4423* (CA); Livingston, April, 1922, *Edith M. Smith & J. C. Menker 120* (CPS). Monterey County: Mansfield ranch, Santa Lucia Mountains, May, 1897, *A. Eastwood* (CA); same, April, 1915, *A. Eastwood 4072* (CA); San Lucas, March, 1922, *Edith M. Smith 108* (CPS). Napa County: Palisade, New Pope Valley, May, 1893, *W. L. Jepson* (UC). Riverside County: Banning, 1904, *M. F. Gilman* (UC); Banta, April, 1897, *A. Eastwood* (CA). Sacramento County: Del Paso Park, April, 1920, *A. A. Heller 13384* (UCX).

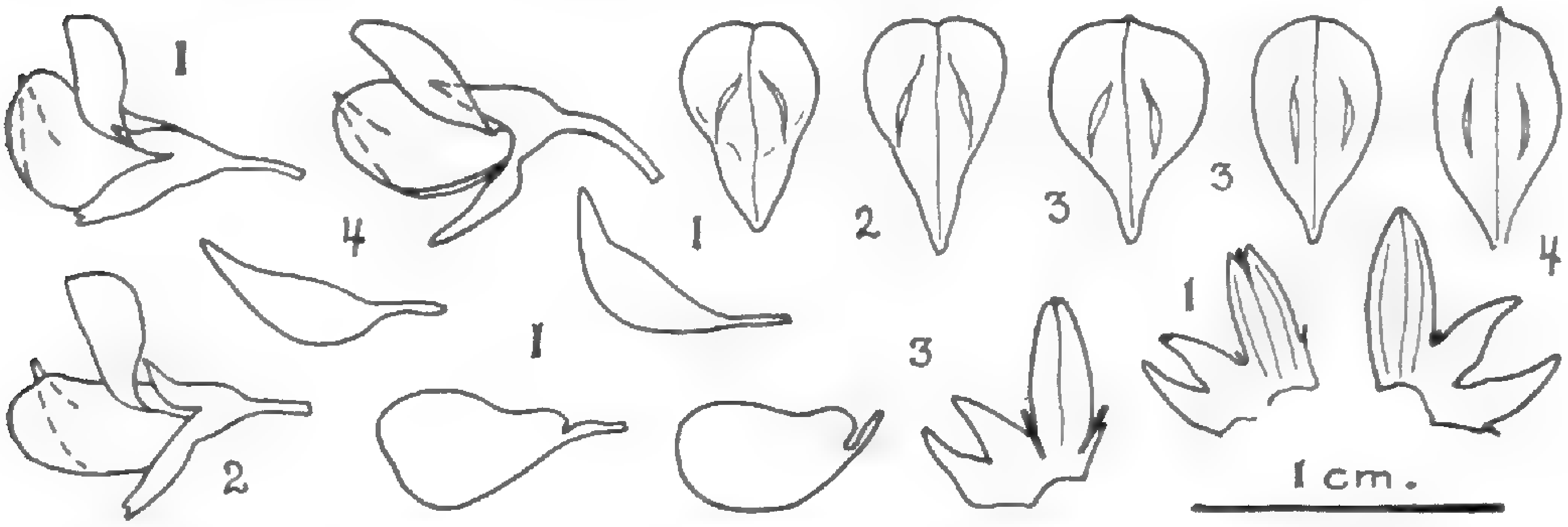


FIG. 88. LUPINUS BICOLOR PIPERSMITHII (Heller) C. P. Smith. 1. *C. P. Smith 1403* (CPS); 2. *C. P. Smith 1402* (CPS); 3. *C. P. Smith 3264* (CPS); 4. *C. P. Smith 3266* (CPS).

San Benito County: San Juan, May, 1903, *A. D. E. Elmer 4914* (CA, DS); same, May, 1922, *C. P. Smith 3517* (CPS). San Francisco County: April, 1886, *T. S. Brandegee* (CA). San Joaquin County: Live Oaks, March, 1877, *V. Rattan* (DS); Stockton, April, 1922, *C. P. Smith 3471* (CPS); Tracy, 1892, *F. T. Bioletti* (UC); same, April, 1903, *C. F. Baker 2910* (BP, UC, US); same, April, 1922, *C. P. Smith 3471* (CPS); Waverly, 1890–91, *J. A. Sanford* (UC). San Luis Obispo County: Paso Robles, March, 1899, *J. H. Barber* (UC). San Mateo County: Stanford Park, April, 1911, *J. I. McMurphey* (DS, CPS); near Stanford University, April, 1908, *C. P. Smith 1402* and *1403* (B, DS, CPS); same, April, 1911, *A. A. Heller 10250* (B, UC, UCX, CPS); same, *A. A. Heller 10251* (UC). Santa Clara County: Betabel, April, 1921, *C. P. Smith 3264* and *3266* (CPS); Gilroy, April, 1921, *C. P. Smith 3257* (CPS); Stanford University, April, 1911, *A. A. Heller 10253* (B, BP, DS, CPS). Santa Cruz

County: Chittenden, April, 1921, *C. P. Smith 3260* (CPS): Glenwood, 1914, *H. Davis* (CA); Rays, June, 1890, *W. Price* (CA). Stanislaus County: Ceres, April, 1916, *W. W. Wagner* (DS); Modesto, 1917, *K. Brandegee* (UC); Oakdale, April, 1922, *C. P. Smith 3477* (CPS). Tulare County: Tulare, April, 1897, *J. B. Davy 3048* (UC); same, March, 1914. *A. Eastwood 384* (CA).

6e. **Lupinus bicolor microphyllus** (Wats.) comb. nov. [FIG. 89.]

Lupinus micranthus microphyllus Wats. Proc. Am. Acad. **8:** 535. 1873.

Lupinus rostratus Eastwood, Proc. Cal. Acad. II. **6:** 424. *pl. 56.* 1896.

Plants 10–40 cm. tall, the branches depressed, decumbent, ascending, or erect; leaflets linear-oblanceolate, oblanceolate, or cuneate, 6–25 mm. long, 1.5–3 mm. wide; flowers 4–5 mm. long, verticillate, umbellate, or alternate, banner elliptic, obovate, or orbicular-spatulate, acute or rounded at apex, 5–7 mm. long by 2–4 mm. wide, keel commonly nearly straight, though sometimes quite arcuate, ciliate and with slender, acute acumen; pods usually 10–15 mm. long; seeds usually pale in color, but sometimes with dark markings, about 2 mm. long.

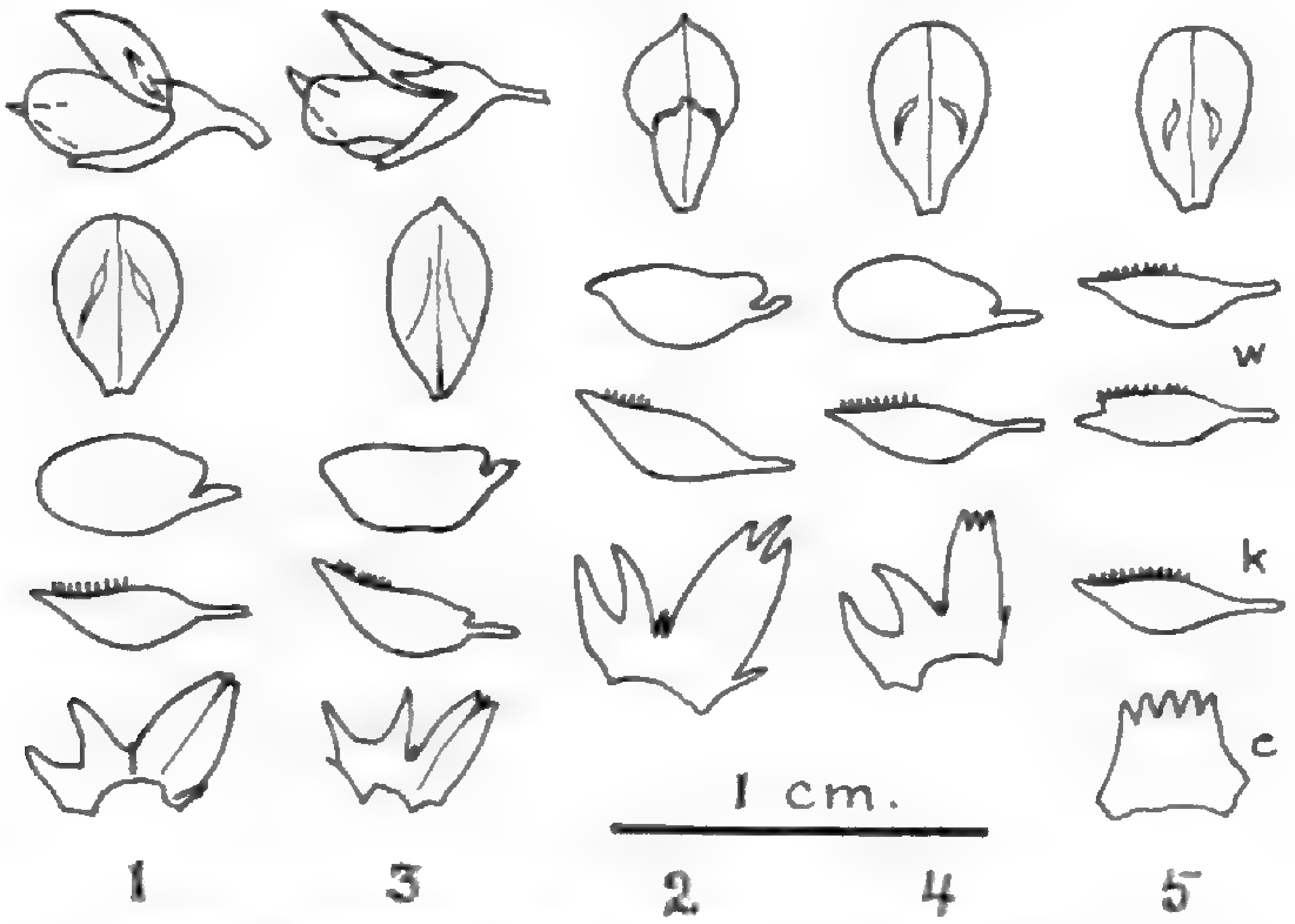


FIG. 89. LUPINUS BICOLOR MICROPHYLLUS (Wats.) C. P. Smith. 1. *G. L. Moxley 947*, San Bernardino County (CPS); 2. *C. P. Smith 2854*, Los Angeles County (CPS); 3. *A. Eastwood 2*, Santa Barbara County (CPS); 4. *L. Jared*, San Luis Obispo County (UC 16012, normal flower); 5. Same as last (UC 16012, abnormal flower; *w*, two wing petals, ciliate as the keel; *k*, keel, normal; *c*, calyx, very abnormal).

Differs from *L. micranthus* in having the *L. bicolor* type of flower, including keel, and from *L. bicolor* proper in the much reduced size of the flowers. The soil-moisture relations evidently have much to do with the stature, size of leaflets, length and density of pubescence, and, perhaps, color of the seeds. Watson's characterization of the variety is not much in itself, but I am satisfied that the plants assigned here include the form for which Watson borrowed Nuttall's manuscript name. The original description is as follows:

> (*L. microphyllus*, Nutt. MS.) A lower and more hirsute form, with leaflets 3–6 lines long. San Diego.

L. rostratus Eastwood is, as I see it, a teratological variation, in line with *L. scaposus* Rydb. (see Bull. Torrey Club **46:** 397. 1919).

This is the dominant variety in Southern California, where it has long been known as *L. micranthus.* From this region, where it is evidently very common, it extends locally northward as far as southern Oregon. I include here two of Greene's manuscript species.

OREGON. Yamhill County: dry open slopes, May, 1878, *Mrs. R. W. Summers 155* (UC).

CALIFORNIA. Amador County: Ione, *K. Brandegee* (CA); Jackson, May, 1891, *G. Hansen 339* (DS). Butte County: Chico, April, 1903, *E. P. Copeland*, Baker distribution 3032 (UC). Calaveras County: Mokelumne Hill, *F. E. Blaisdell* (CA, CPS). Contra Costa County: Brentwood, May, 1893, *A. Eastwood* (CA); Point Isabel, July, 1911, *K. Brandegee* (UC). Eldorado County: Pilot Hill, April, 1915, and May, 1909, *K. Brandegee* (UC). Fresno County: Zapato, March, 1893, *A. Eastwood* (CA); Big Sandy Creek, April, 1915, and April, 1916, *Julia McDonald* (CA). Glenn County: Colusa, April, 1921, *A. Eastwood 10244* (CA). Humboldt County: Willow Creek, May, 1919, *J. P. Tracy 5149* (UC). Kern County: Bakersfield, April, 1893, *A. Eastwood* (CA); Caliente, *K. Brandegee* (UC); same, April, *T. S. Brandegee* (CA); Delano, April, 1893, *A. Eastwood* (CA); Havilah, *K. Brandegee* (UC); Isabella, April, 1915, *B. W. Evermann* (CA); Kernville, May, *T. S. Brandegee* (CA). Lake County: Lower Lake, May, 1903, *C. F. Baker 2983* (BP, UC, US). Los Angeles County: Barley Flats, San Gabriel Mountains, July, 1921, *G. L. Moxley 1028* (CPS); Ballona hills, March, 1921, *G. L. Moxley 906* and *940* (CPS); Antelope Valley, south side, May, 1902, *H. M. Hall 3068* (UC); Los Angeles, Feb., 1902, and April, 1903, *Miss E. D. Palmer* (UC); Manzana, May, 1896, *J. B. Davy 2544* (UC); Pasadena, April, 1905, *G. B. Grant* (CA, DS, UC); Santa Catalina, May, 1916, *K. Brandegee* (UC); Santa Monica Mountains, March, 1916, *Crawford & Hiatt* (BP); plus some thirty other collections. Mariposa County: Blochman ranch, *A. Eastwood 4253* (CA). Monterey County: Big Pinnacles, April, 1919, *R. S. Ferris 1734* (DS); Jolon, April, 1915, *A. Eastwood 4142* (CA); Pacific Grove, March, 1921, *Edith M. Smith 103* (CPS); San Antonio Creek, May, 1895, *W. R. Dudley* (DS); Sur River, June, 1893, *A. Eastwood* (CA). Riverside County: Banning, March, 1919, *Munz, Street, & Williams 2375* (BP, DS); Cabazon, March, 1919, *Munz, Street, & Williams 2460* (BP); Corn Springs, Chuckwalla Mountains, April, 1922, *P. A. Munz & D. Keck 4845* (CPS); Hemet, April, 1904, *C. F. Baker 4100* (BP, DS); Keen Camp, May, 1922, *F. W. Pierson 3064* (CPS); same, *Munz & Johnston 5427* (CPS); Sedco Station, April, 1922, *P. A. Munz 5079* (CPS). San Benito County: Hernandez, April, 1903, *Laura M. Lathrop* (DS); Tres Pinos, March, 1893, *W. W. Price* (DS). San Bernardino County: Colton, April, 1882, *M. E. Jones 3330* (CA); Hesperia, April, 1888, *S. B. Parish* (UC); same, May, 1920, *I. M. Johnston* (BP); same, May, 1921, *G. L. Moxley 947* (CPS); San Bernardino, April, 1901, *S. B. Parish 4659* and *4662* (DS); Upland, Red Hill, April, 1918, *P. A. Munz 2103* and *2104* (BP); same, *I. M. Johnston 1871, 1974* and *1975* (BP, DS); Yucaipe Valley, May, 1918, *S. B. Parish 11793* (BP); also a few others. San Diego County: Bonsal, May, 1920, *Munz & Harwood 3918* (CPS); Campo, Warren ranch, April, 1920, *A. Eastwood 9391, 9392,* and *9472* (CA); Cuyamaca Lake, July, 1895, *S. G. Stokes* (DS); Descanso, June, 1919, *A. Eastwood 9177, 9177a,* and *9178* (CA); Live Oak Springs, Laguna Mountains, June, 1917, *E. A. McGregor 925* (DS); San Diego, April, 1903, *T. S. Brandegee,* Baker distribution 3363 (B, BP, CA, DS, UC); Witch Creek, 1919, *R. D. Alderson* (UC, plants I and II); also some fifteen others. San Francisco County: April, *K. Curran* (CA). San Luis Obispo County: Avila, *Mrs. R. W. Summers* (UC); Estrella, *L. Jared* (CA, DS, UC); Paso Robles, May, 1920, *A. J. Perkins* (CPS); Pismo, June, 1884, *Mrs. R. W. Summers* (UC); San Luis Obispo, 1886, *M. M. Miles* (CA); Santa Margarita Mountain, April, 1903, *W. R. Dudley* (DS). Santa Barbara County: Ellwood, May, 1908, *A. Eastwood 2* (CA, CPS); Santa Barbara, 1888, *T. S. Brandegee* (CA); Santa Maria, June, 1906, *A. Eastwood 359* (CA); Surf, Antonio siding, *K. Brandegee* (UC). Santa Clara County: Los Gatos, April, 1897, *W. A. Setchell* (UC); San Martin, March, 1915, *L. R. Abrams 5179* (DS); Stanford University foothills, May, 1902, *C. F. Baker 845* (BP, CA, UC); Uvas road, May, 1922, *C. P. Smith 3510* (CPS). Santa Cruz County: Olympia, June, 1921, *C. P. Smith 3403* (CPS). Shasta County: Anderson, April, 1918, *A. A. Heller 12991* (UCX). Sonoma County: Healdsburg, April, 1897, *M. Alice King* (BP, UC). Stanislaus County: March, 1921, *Mrs. B. Hoisholt 104* (CPS); same, *Estella Hoisholt 101* (CPS); same, April, 1922, *C. P. Smith 3473* (CPS). Sutter County: Marysville Buttes, April, 1917, *R. S. Ferris 649* (DS). Tulare County: between Earlimart and Delano, May, 1914, *A. Eastwood 3959* (CA); Grapevine Springs, March, 1898, *P. S. Woolsey* (UC, plant I); Milo, April, 1900, *W. R. Dudley* (DS); Porterville, April, 1907, *Miss L. L. Donnelly 32* (UC); Tule River, March, 1897, *W. R. Dudley* (DS). Ventura County: Mutau Flat, June, 1908, *Abrams & McGregor 190* (DS); Nordhoff, April, 1916, *A. Eastwood* (CA); Ojai, April, 1896, *F. W. Hubby 36* and *37* (UC); Santa Paula, April, 1902, *J. B. Davy* (UC); Ventura, Foster Park, April, 1916, *A. Eastwood 5006* (CA).

LOWER CALIFORNIA. Guadalupe Island, 1898, *Harry Drent* (UC); same, June, 1906, *Brown* (UC); San Sebastian, April, 1889, *T. S. Brandegee* (CA, UC).

SONORA. Casita, May, 1892, *T. S. Brandegee* (UC).

6f. **Lupinus bicolor tetraspermus** var. nov. [FIG. 90.]

Varietas caulibus petiolisque angustissimis; foliolis lineare-filiformibus; floribus 4–5 mm. longis, labio superiore calycis 2 mm. longo inferiore 3 mm. longo, vexillo late obovato, carina ciliata; leguminibus 10–12 mm. longis, 3 mm. latis, aliquantum constrictis, seminibus saepius quattuor, interdum quinque permaculatis vix 2 mm. longis.

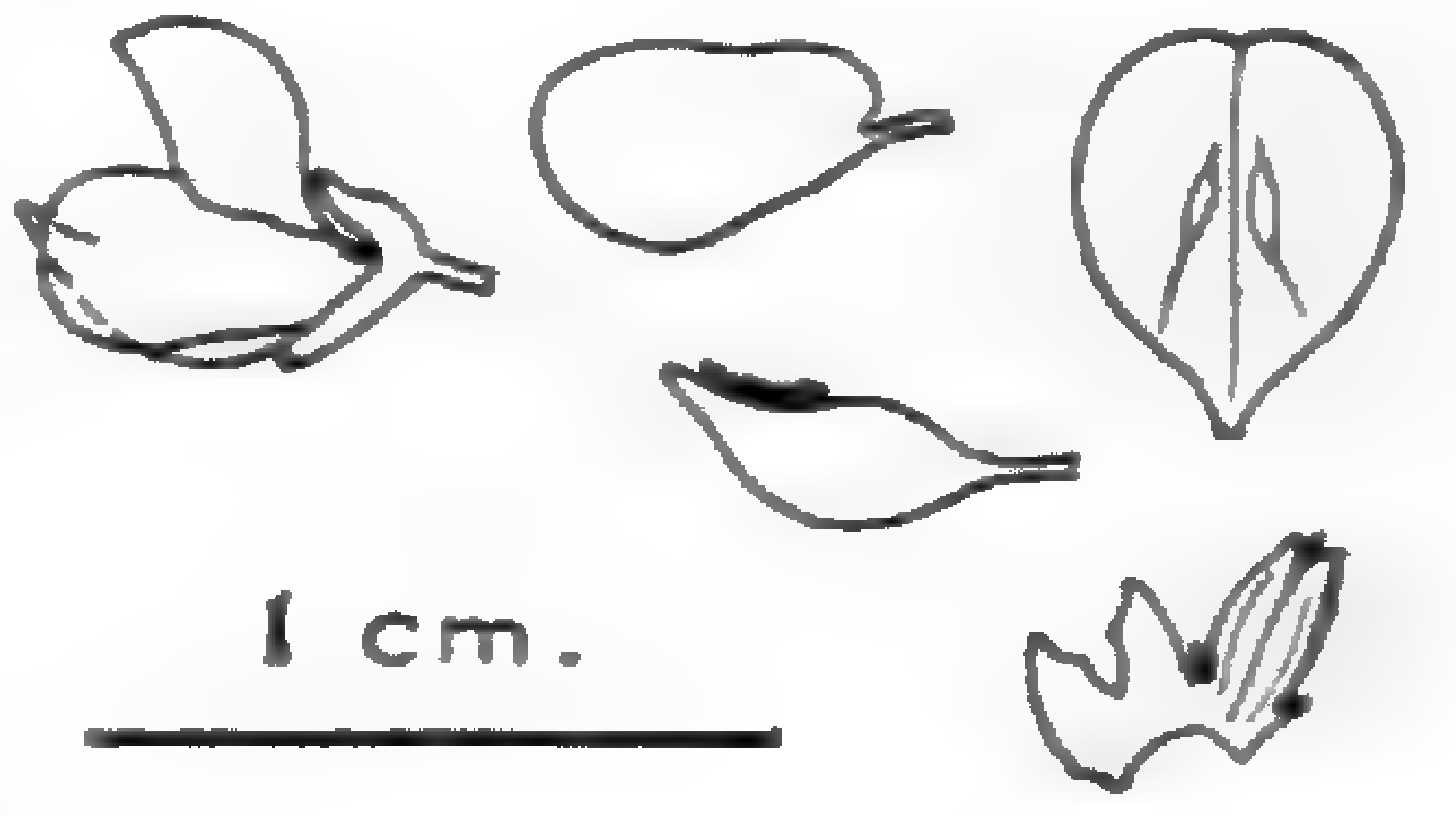


FIG. 90. LUPINUS BICOLOR TETRASPERMUS C. P. Smith. *C. P. Smith 3405* (CPS).

Stems and petioles filiform, leaflets linear-filiform, 10–20 mm. long; flowers 4–5 mm. long, banner orbicular-obovate, 6 mm. long by 5 mm. wide, keel ciliate, upper calyx-lip 2 mm. long, lower 3 mm. long; pods 10–12 mm. long, 3 mm. wide, much constricted, suggesting those of *Vicia tetrasperma*; seeds more often four, but sometimes five, scarcely 2 mm. long by about 1.5 mm. wide, heavily marked.

CALIFORNIA. Santa Clara County: Wright, June, 1921, *C. P. Smith 3405* (TYPE, DS; type-duplicates CA, G, UC, CPS).

This is a very odd extreme with the aspect of a good species, but undoubtedly to be considered a variety of *L. bicolor*.

6g. **Lupinus bicolor trifidus** (Torr.) comb. nov. [FIG. 91.]

Lupinus micranthus trifidus Wats. Proc. Am. Acad. **8:** 535. 1873.
Lupinus trifidus Torr.; Wats. Proc. Am. Acad. **12:** 250. 1877.

Watson's second characterization of this form is as follows:

> Very closely resembling *L. micranthus*, but the lower lip deeply 3-cleft with linear segments: pod narrower and shorter (about 6 lines long and 1½ broad), usually 5-6-seeded: seeds a line broad, uniformly mottled: flowers 3 lines long or less, mostly in a single terminal whorl.—*L. micranthus*, var. *trifidus* Watson, Rev. Lup. 535. Near San Francisco, by various collectors, and recently in fine specimens by Mr. G. R. Vasey. The ordinary *L. micranthus*, besides the nearly entire lip, has a pod often an inch long and 2½ lines broad, 6-9-seeded, and the large seeds variously mottled, but with a lighter spot around the sometimes dark eye.

Although I once (Muhlenbergia **6:** 137. 1911) held this to be a distinct species, I now see no substantial excuse for so treating it. Its relationship, however, is evidently with *L. bicolor* rather than with *L. micranthus*. Its deeply trifid lower calyx-lip is its one outstanding peculiarity.

Seemingly peculiar to the San Francisco and Monterey sandy areas, its occurrence at San Juan, San Benito County, calls for special consideration. Elmer's specimens show a habit and stature not at all like the usual plants, and the calyx character (see figure) was not recognized by me until dissection of a flower was made. In May, 1922, I visited San Juan to study this variant in the field; but I found vars. *tridentatus* and *Pipersmithii* only. While Elmer's plants may represent a non-persisting mutation from the common var. *tridentatus*, I hold the opinion that they are mere non-persisting climatic or soil variants originating from seed casually introduced from the Monterey region, San Juan being on the much traveled San Francisco-Monterey highway.

CALIFORNIA. Monterey County: Del Monte, May, 1888, *B. F. Leeds* (DS); same, March, 1921, *C. P. Smith 3241* and

3244 (CPS); Pacific Grove, April, 1902, *A. D. E. Elmer 3512* (UC); same, April, 1903, *A. A. Heller 6631* (B, BP, DS, UC); June, 1907, *C. P. Smith 1358* (CPS); same, March, 1921, *Edith M. Smith 105*, *106*, and *107* (CPS); Seaside, April, 1894, *W. R. Dudley* (DS); same, March, 1910, *Alice D. Randall 230* (DS). San Benito County: San Juan, May, 1903, *A. D. E. Elmer 4910* (BP, DS). San Francisco County: Lake Merced, May, 1893, *Michener & Bioletti* (UC); San Francisco, May, 1884, *M. K. Curran* (DS, UC); same, Jan., 1893, *J. B. Davy 1169* (UC). San Mateo County: Colma, back of cemeteries, April, 1908, *C. P. Smith 1423* (DS, CPS); South San Francisco, April, 1908, *C. P. Smith 1419* (CPS).

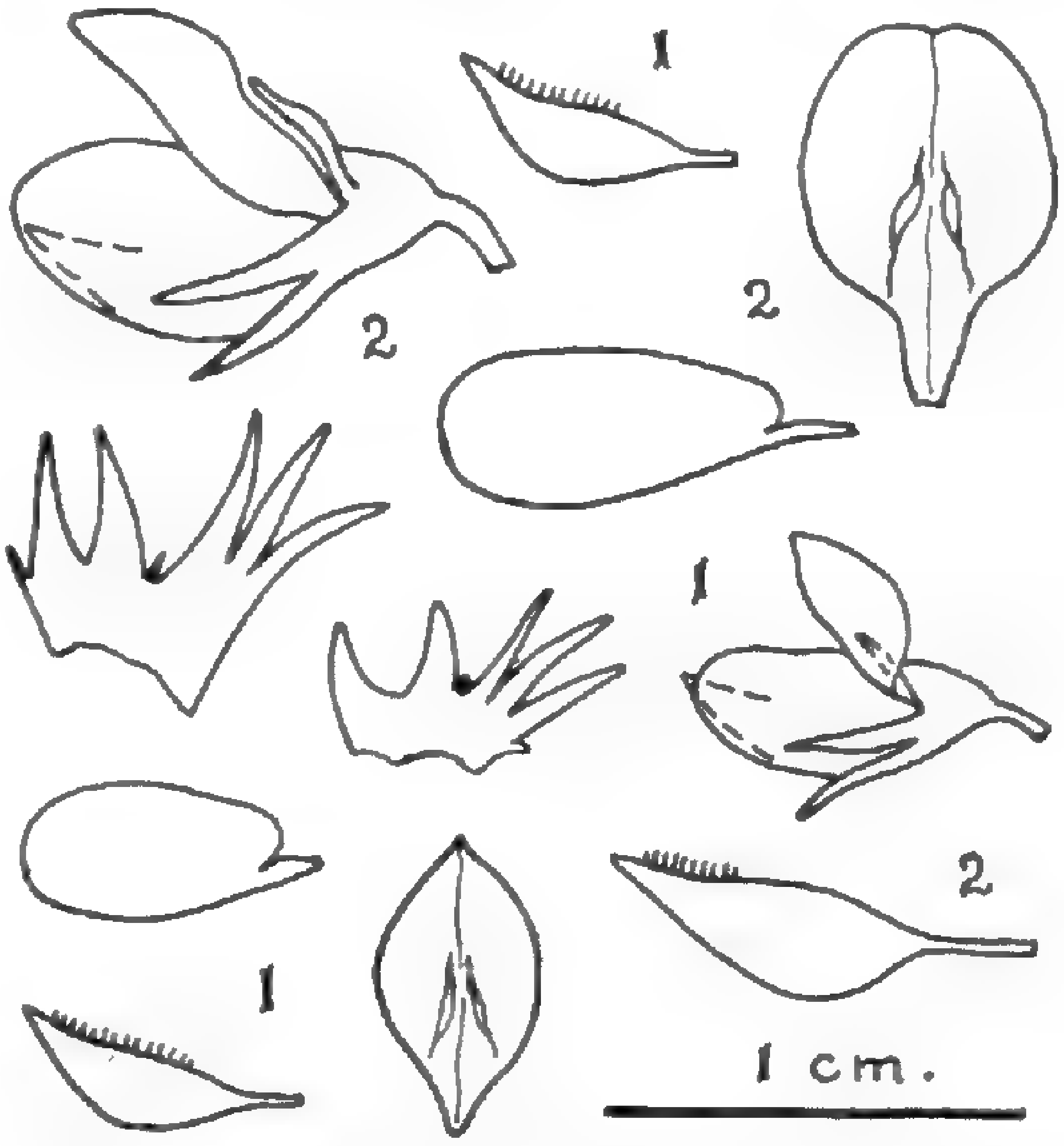


FIG. 91. LUPINUS BICOLOR TRIFIDUS (Torr.) C. P. Smith. 1. *C. P. Smith 1423*, San Francisco (CPS); 2. *A. D. E. Elmer 4910*, San Juan (DS).

Lupinus bicolor, as herein interpreted, would form a most interesting subject for genetic investigations, such as recently concluded and reported upon by Dr. Burlingame (Am. Nat. **55:** 427–448. 1921).

The following list will identify the abbreviations here used in the citation of specimens examined:

B, Brooklyn Botanic Garden;

BP, C. F. Baker Herbarium, Pomona College, Claremont, California;

CA, California Academy of Science, San Francisco;

CPS, herbarium of the writer;

DS, Dudley Herbarium, Stanford University;

G, Gray Herbarium, Harvard University;

NY, New York Botanical Garden;

UC, Department of Botany, University of California;

UCX, Division of Agronony, University of California Experiment Station;

US, United States National Herbarium.

SAN JOSE, CALIFORNIA

Intracellular relations of aggregate crystals in the spadix of Anthurium

L. O. GAISER

(WITH PLATE 20)

The current views as to the relation of crystals to other contents of the cell, and especially the nucleus, have recently been sharply questioned by Jeffrey (**5**). Jeffrey denies that the compound crystals of calcium oxalate, found abundantly by him in the pith, cortex, and phloem of *Ginkgo*, as well as in some of the Dicotyledons, arise by a process of crystallization in the fluid of the cell sap. He considers *Ginkgo* the most favorable for study and finds that cells near the growing point, which are to contain crystals, are easily distinguishable by a centrally placed nucleus about which the crystals are formed. He states:

> From the very beginning the crystals occupy practically the whole lumen of the cell and more or less protoplasm surrounds the nucleus which is the organic centre of the druses. The crystals in fact constitute an irregular spiny casing which surrounds the nucleus and protoplasm.

He states further that "in very large and old crystals indications of the presence of a nucleus can frequently be demonstrated by appropriate methods." Species of the dicotyledonous families Juglandaceae, Cactaceae, Begoniaceae, and Geraniaceae differ from *Ginkgo* in that "the nucleus becomes obscured at a much earlier stage of development of the crystal and not infrequently the latter does not occupy the whole lumen of the cell as in *Ginkgo*."

Lloyd (**9**), on the other hand, in a further study of leaves from growing buds of *Ginkgo*, confirms the commonly accepted view and finds in older cells, in which the crystals were large enough to occupy the greater portion of the total volume of the cell, the nucleus crowded against the cell wall and between projecting crystals of the druse. He speaks also of "colloidal material being imprisoned in the druse." Jeffrey (**6**), however, in a second paper nowhere speaks of the nucleus being surrounded by the crystal but makes such statements as the following: "The central body in crystals is in fact not only clearly observable but is likewise very far from being unsubstantial."

While making a more general cytological study of *Anthurium* I have observed numerous cells containing stellate crystals in which the relations of these crystals to the nucleus and other cell elements can be seen with great clearness. There is an abundant literature dealing with the position of the crystals in plant cells. Wakker (**23**), using De Vries' method, 10 per cent potassium nitrate and eosin solution, for studying the vacuolar membrane, examined cells of *Anthurium Hookeri*, containing various crystal formations. For such studies the crystal druses, he claims, give the greatest difficulty since the plasma and vacuole wall die simultaneously and it is thus difficult to isolate the vacuoles. However, occasionally favorable preparations were obtained and he describes a cell containing a vacuole in which lay a very young druse. He gives no illustrations of the *Anthurium* but for *Hoya carnosa* figures a cell from a leaf showing very clearly that the stellate crystal there lies in the vacuole. For *Ricinus communis* a row of cells gives similar evidence. After a detailed description of the finding of crystals in vacuoles in *Hoya carnosa*, *Anthurium Hookeri*, and *Ricinus communis* he lists all the plant organs in which such crystal aggregates are claimed to be similarly situated. In summarizing he claims that calcium oxalate is never deposited in the plasma but only in the vacuole. As to the position and appearance of the nucleus he makes no special statement.

The material I have studied consists of spadices of various *Anthurium* species, fixed in Flemming's strong and medium chromic-osmic-acetic solutions for twenty-four and forty-eight hours. Sections were cut 5 μ, 7.5 μ, 12 μ, and 18 μ thick, and stained chiefly with the triple gentian-safranin-orange G stain, though the double fuchsin and iodine green stain was also used. Calcium oxalate crystals of the aggregate or stellate type were found in great abundance through the central axis of the spadix and in the perianth. These crystals give the ordinary test for calcium oxalate, i. e., solution in nitric acid and in hydrochloric acid without formation of gas bubbles. My drawings are all from preparations of *Anthurium grande*. Other species studied were *Anthurium acaule*, *A. Andreanum*, *A. gracile*, *A. Guildingii*, *A. magnificum*, *A. Olfersianum*, *A. scandens*, *A. Scherzerianum*, *A. variabile*, and a small unidentified epiphytic species from Panama growing in the Columbia University greenhouse. The other species are growing in a plant house of the New York Botanical Gardens.

Cells with stellate crystals are not as prominent as raphide-bearing cells, which are also plentiful in this material. The latter are always greatly enlarged cells with prominent nuclei, as described by Miss Smith (**22**) for the orchids, while the former give little evidence of cell hypertrophy or abnormal nuclear size. In this connection it may be noted that Samuels (**19**), in a recent paper, reports finding in *Anthurium scandens* and *A. Scherzerianum* large raphide-containing cysts, which are pathological and arise as the result of the fusion of several cells and of their nuclei. Ordinary raphide-bearing cells also occur and differ from the cysts in that no nuclear or cell fusions occur.

In the older tissues of *Anthurium grande* the crystal aggregate fills almost the entire lumen of the cell and the nucleus can be seen near the wall between the points of the crystals, as described by Lloyd for *Ginkgo*. Smaller crystals are found in otherwise undifferentiated parenchymatic cells that are no larger than normal adjoining cells, as can be seen in FIG. 3. Their nuclei, though perhaps shifted to one side or perhaps more noticeably to one end of the cell, are of normal size, and give evidence from their appearance that they are still truly functional. They are usually spherical or ellipsoidal in shape. In sections stained with the triple stain the one or more nucleoli stand out sharply against the more dispersed chromatin as it appears in an ordinary resting nucleus (FIGS. 1, 2, 3).

The cells of these tissues are already vacuolated. Younger ones toward the tip of the spadix showed numerous vacuoles with the nucleus in the centre of the cell; the older cells have one large central vacuole with nucleus and primordial utricle lying next to the cell wall. All the pith cells of the central axis had reached the latter stage, while those in the perianth varied. Many were still in process of division, and small stellate crystals could be seen in cells adjoining those with spindle figures.

In FIG. 1 is shown a subepidermal cell from a perianth part with a comparatively small crystal group, little larger than the cell nucleus, whose nearly spherical shape and almost central position are quite evident. The cytoplasm shows numerous vacuoles and in one of these the crystal apparently lies, though the vacuolar membrane cannot be followed all the way round.

In FIG. 3 the crystal clearly lies in a normally spherical-appearing vacuole. As drawn, the tonoplast on the upper side overlaps the crystal, but that is the result of its being drawn at a higher plane. The primordial utricle next to the wall is quite distinct. By a slight shrinkage the plasma membrane has been sufficiently drawn away from the wall to become sharply distinguishable. The nucleus, which approximates the size of that in the normal cell next to it, lies imbedded in the cytoplasm, while the crystal appears as an inclusion in the vacuole. By the number of walls adjoining those of the cell (FIG. 1) it might appear that that cell was very much hypertrophied. However, it is merely so by contrast to the smaller epidermal cells by which it is bounded along two sides.

Cells containing larger crystal aggregates show a thin primordial utricle, as is usual in older cells, when a large vacuole occupies the centre of the cell. FIG. 4 shows two cells from the pith of the spadix. The one to the right is a normal parenchymatous cell, somewhat elongated, and lacking any stainable vacuolar content. The nucleus is appressed to the cell wall, lying in a primordial utricle that also contains scattered chloroplasts. The adjoining cell appears more isodiametric because of the large almost radially symmetric crystal aggregate, looking like a sunburst, that occupies its central region. There is little difference in the remaining contents of the two cells, cytoplasm, chloroplasts, and nuclei, are equally large and of normal appearance. Adjacent to the intercellular spaces the walls of the two cells are seen to be of the same thickness unlike those described by Lloyd in *Ginkgo*. He describes the large druse as surrounded by a thin cell wall which has never acquired the thickness of those of the living neighboring cells. It will be noticed that the intercellular spaces (FIG. 4) are smaller to the right of the normal cell than to the left of the crystal-containing cell due to the fact, however, that the former approaches a vascular bundle region where the cells are more closely crowded.

FIG. 5 represents a still larger crystal also from the pith region when the primordial utricle has become very scant, almost unnoticeable except as a plasma membrane, which however shows quite clearly in some places. The individual crystals extend almost to the cell wall into this thin layer and in some cases the colloidal mass extends inwards sheathing the crystal tips for a short distance.

As noted, Wakker considered the proof adequate that the origin of crystals is in the vacuole. Kohl (**8**), on the other hand, held to their origin in the mass of the colloidal cytoplasm itself. In classifying calcium oxalate crystals in respect to the positions they occupy in the plant cell he recognized three types. They may: (1) appear as inclusions in the protoplast; (2) be lodged in the membrane; or, finally, (3) be attached to the cell wall. If crystals may appear in the cell membrane and are surrounded by a cellulose sheath, Kohl considered it probable that they originate in the cell plasma, since only by its activity could the crystal be encapsuled by a cellulose sheath.

Pfeffer (**15**, p. 95) considered the possibility of a passage of crystals through the plasma. In the plasmodia of Myxomycetes he claims amoeboid movements serve mechanically in taking into the substance of the protoplasm foreign particles. These are carried to the interior and, penetrating the vacuoles, are expelled from time to time. Crystals like other solid bodies might be so transferred and in protoplasts bounded by a cell wall would collect in the cell sap.

The proof that crystals, either clearly visible in the vacuole or less evidently so, are surrounded by a plasma sheath is probably inadequate. The older observation of Payen (**14**) of aggregates of crystals so enclosed in the cells of Cacti needs confirmation. In general, acids have been used to first dissolve the salt and leave the crystal sheath. Such methods of determination involve the risk of inaccuracy, since the possibility that the so-called sheath is a precipitation or shrinkage product is not sufficiently considered. Osterhout (**12**) has shown that shrinkage may be caused by other means than the use of hypertonic solutions.

Deviations from the general occurrence of plasmolysis in a cell when placed in a solution whose osmotic pressure exceeded that of the cell sap led him to suspect that a contraction of the protoplasm might be due to the chemical action of a salt. This conception was confirmed by finding that plasmolysis of *Vaucheria* zoospores in a 0.0001 m. solution of NaCl was prevented when a little $CaCl_2$ was added. By putting in the minute amount of one molecule for every hundred molecules of NaCl the protoplasm of the algal cells showed no contraction even though the solutions reached one thousand times greater osmotic pressure

(0.1 m.). His interpretation is that the contraction was caused by the penetration of the NaCl producing chemical effects upon the protoplasm rather than by the greater osmotic pressure of the salt solution. This behavior Osterhout has called false plasmolysis. He (**13**) later described such effects from pure distilled water. There he explained the result as due to an increase in permeability of the plasma membrane, by which some or all of the substances which maintain the osmotic pressure of the cell diffuse out. An apparent "coagulation" of the protoplasm resulted which is not to be confused with true plasmolysis.

In this connection such a figure as FIG. 2 is interesting. The small crystal aggregate lies in a large central vacuole surrounded by the primordial utricle with nucleus, somewhat shrunken from the wall. A delicate strand running from one of the crystals to the vacuolar wall is noticeable, having stained yellow with orange. On other crystals also there appear very delicate similarly-staining extensions. If, as is generally conceded, (see Meyer, **10,** p. 57; Sharp, **21,** p. 135; Osborne, **11,** p. 7; and, especially for idioplasts, Heinricher, **4,** and Schneidler, **20**) and as is regarded as probable but not proven by Pfeffer (**15,** p. 82) there are soluble protein materials in the vacuole these would quite probably be coagulated by fixation and may account for such appearances. With our present inadequate knowledge of stains and tests for minute quantities of protein in the cell there is difficulty in deciding the true nature of such materials.

It is of interest here to note that the so-called Rosanoff crystals, although first found by Rosanoff (**16**) in the pith of *Kerria japonica* and *Ricinus communis*, were found but little later by him (**17**) in sacs accompanying the vascular bundles of the petioles of the Aroideae, among them *Anthurium rubricaule* and *A. Selloum*, as well as in the parts of the flower of *Encephalartos* and *Nelumbium*. His figures show stellate crystals of calcium oxalate connected with the cell wall by strands which he claimed are cellulose, "Cellulosebalken," or the crystal may simply project from the cell wall. By treating the cell with nitric acid which dissolved the oxalate of lime there remained the strands, and also what he considered to be the sheath that had surrounded the crystal. His figure of a cell so treated shows a shrunken mass and suggests that the protoplast may have suffered from the same traumatic effects as those described by Osterhout.

De la Rue (**2**) a little later gave further confirmation of Rosanoff's crystals. He reported them in the leaf of *Hoya carnosa* and in the petioles of *Pothos crassinervius* (*Anthurium Hookeri*) and *Philodendron pertusum*. In his rather crude figure (*f. 3*) of a cell of *Hoya carnosa* he includes a nucleus and chloroplasts. Rosanoff (**17**) gives a figure of a cell of *Anthurium Selloum* (*f. 4*) showing the nucleus lying somewhat beneath the crystal and in the conclusion of his paper states that he finds the nucleus unaltered in these crystal-bearing cells. Both of these statements were made in refuting the statement in an earlier text-book of Duchartre (**3**), "Les celles dans les quelles existent des cristaux ne refernment pas d'autres matières solides."

Wittlin (**24**) has also confirmed Rosanoff. In an extensive investigation of various tissues he frequently found the crystal with a cellulose sheath accompanied usually by cellulose strands. This was the case in the pith of stems of *Kerria japonica*, in the pith of internodes of *Caesalpinia Sapan*, and *Tilia* (tissue not mentioned). In the fundamental tissue of stems and petioles of *Philodendron pertusum* (*Monstera deliciosa*) and *P.* "*argyrea*", and *Morus alba* (tissue also not mentioned), the strands were found to be very short and broad or lacking altogether. For his study he used fresh material and cut successive sections from the growing point backward. In younger regions of stems of *Kerria japonica*, about 1.5 mm. in thickness, he found the crystal lying in the plasma with the nucleus also visible. Cutting further he found successively larger crystals in cells whose plasma with the nucleus was contracted about the crystal, until in stems 2.5 mm. thick he found the crystals touching the cell wall. At this late stage in development the formation of the cellulose membrane about the crystal occurs, beginning at the point of contact of the crystal with the cell wall. With the growth of the cell a so-called foot is formed, which broadens and becomes stretched into a strand that pushes the crystal with its sheath towards the center of the cell. The plasma is partly used and partly displaced. The nucleus becomes invisible at the first appearance of the cellulose strands (**24,** *pl. 1, f. 1–4*). In *Caesalpinia Sapan* similar appearances were found although the elaioplasts and plasma persist after the nucleus becomes invisible. The presence of the nucleus in cells containing small crystals and its later disappearance he regards as constant.

Johow (**7**) studied members of the families Aroidaceae, Commelinaceae, Amaryllidaceae, Iridaceae, and Orchidaceae, with the object of determining whether nuclei or any protoplasmic body were present in mature tissue cells. He worked with fresh material, using staining reagents to differentiate the cell content. In such cases as the raphide cells, where it was impossible to investigate sections of living tissue because the rows of sacs could not be kept intact for their whole length, he had recourse to alcoholic material, of which single cells were isolated by maceration methods and then stained. Johow reached the conclusion that in all secretory reservoirs observed by him, including slime-containing raphide sacs, *drusen* cells, latex-containing sacs, tannin sacs and tannin-containing septate latex tubes, protoplasm and nucleus were regularly present. Of the aroids he observed *Anthurium sagittatum* and *Philodendron cordifolium* and found in older stems and leaf petioles the characteristic Rosanoff crystals. He describes them as filling almost entirely the lumen of the cell, being connected by cellulose strands to the wall and enclosed by a cellulose membrane. As Rosanoff had observed, he too found the unchanged nucleus with a nucleolus. He points out that the nucleus lies in a well developed primordial utricle along the cell wall and not adjacent to the crystal.

Kohl (**8**), also working in the petiole of *Anthurium Scherzerianum*, found nuclei lying in the cytoplasm of the crystal cells and confirmed Rosanoff's findings as to the presence of a cellulose sheath about the crystals (see also Meyer, **10**, p. 381) but the same method of treatment by nitric acid was employed. I have sections of an *Anthurium* petiole which give data bearing on the problem of the cellulose sheath on which I shall report in a later paper.

Kohl is very clear on the question here involved as to the presence of the nucleus in the primordial utricle and outside the crystal group. Johow's criticism of the text-books of Sachs (**18**) and De Bary (**1**) for assuming that there are no other solid bodies in a crystal-containing cell is entirely justified.

As for the nucleus in *Anthurium grande*, it persists intact in the cell after the crystal has become a conspicuous stellate structure in a vacuole. When the size of the crystal is such as to occupy almost the entire lumen of the cell the nucleus is still in evidence in a thin primordial utricle not only in this species but in the others mentioned earlier. In these forms there is certainly no evidence that the nucleus ever forms the centre about which a stellate group of crystals develops.

In conclusion I wish to thank Professor R. A. Harper for his suggestions and careful criticism of this work.

BIBLIOGRAPHY

1. **De Bary, H. A.** Comparative anatomy of the vegetative organs of the phanerogams and ferns. English Translation. Oxford. 1884.
2. **De La Rue, E.** Über Krystalldrüsen bei einigen Pflanzen. Bot. Zeit. **33:** 537–539. *f. 1–5.* 1869.
3. **Duchartre, P.** Éléments de Botanique. Paris. 1867.
4. **Heinricher, E.** Über Eiweissstoffe führende Idioblasten bei einigen Cruciferen. Ber. Deutsch. Bot. Ges. **2:** 463–466. 1884.
5. **Jeffrey, E. C.** The cytology of vegetable crystals. Science II. **55:** 556, 557. 1922.
6. ——— Professor Lloyd and vegetable crystals. Ibid. II. **57:** 442–444. 1923.
7. **Johow, F.** Untersuchungen über die Zellkerne in den Secretbehältern und Parenchymzellen der hoheren Monocotylen. Bonn. 1880.
8. **Kohl, F. G.** Anatomisch-physiologische Untersuchungen über die Kalksalze und Kieselsäure in der Pflanze. Marburg. 1889.
9. **Lloyd, F. E.** The cytology of vegetable crystals. Science II. **57:** 273, 274. 1923.
10. **Meyer, A.** Morphologische und physiologische Analyse der Zelle der Pflanzen und Tiere. 1920.
11. **Osborne. T. B.** The vegetable proteins. 1909.
12. **Osterhout, W. J. V.** On plasmolysis. Bot. Gaz. **46:** 53–55. 1908.

13. **Osterhout, W. J. V.** Protoplasmic contractions resembling plasmolysis which are caused by pure distilled water. Ibid. **55:** 446–451. 1913.

14. **Payen, A.** Cinquième mémoire sur les développement des végétaux. Mém. Sav. Etrang. **9:** 77–126; **8:** *pl. 1–8.* 1846.

15. **Pfeffer, W.** Pflanzenphysiologie. Ed. 2. Leipzig. 1897.

16. **Rosanoff, S.** Über die Krystalldrüsen im Marke von *Kerria japonica* und *Ricinus communis.* Bot. Zeit. **4:** 329, 330. *pl. 12 + f. 1–6.* 1865.

17. ———— Über Krystalldrüsen in den Pflanzenzellen. Ibid. **6:** 41, 42. *pl. 2a.* 1867.

18. **Sachs, J.** Text book of botany. English translation. Oxford. 1882.

19. **Samuels, J. A.** A pathological anatomical study of crystal cyst formation in parenchymatous tissue in the genus *Anthurium.* Ann. Bot. **37:** 159–181. *pl. 2 + f. 1–5.* 1923.

20. **Schweidler, J. H.** Die Eiweiss- oder Myrosinzellen der Gattung *Arabis* L. Bot. Centralbl. Beih. **26^1:** 422–475. *f. 1–54.* 1910.

21. **Sharp, L. W.** An introduction to cytology. New York. 1921.

22. **Smith, E. S.** The histology of certain orchids with reference to mucilage secretion and crystal formation. Bull. Torrey Club **50:** 1–16. *pl. 1.* 1923.

23. **Wakker, J. H.** Studien über Inhaltskörper der Pflanzenzelle. Jahrb. Wiss. Bot. **19:** 423–496. *pl. 12–15.* 1888.

24. **Wittlin, J.** Über die Bildung der Kalkoxalat Taschen. Bot. Centralbl. **67:** 33–41, 65–73, 97–102, 129–133. *pl. 1.* 1896.

Explanation of plate 20

The figures were drawn with the aid of a camera lucida from sections 12 µ and 18 µ thick of the spadix of *Anthurium grande.* In representing the crystals no attempt was made to show the crystals in perspective. Apices merely are outlined. FIGS. 1, 2 and 3 are magnified approximately 1950 times; FIGS. 4 and 5, approximately 980 times.

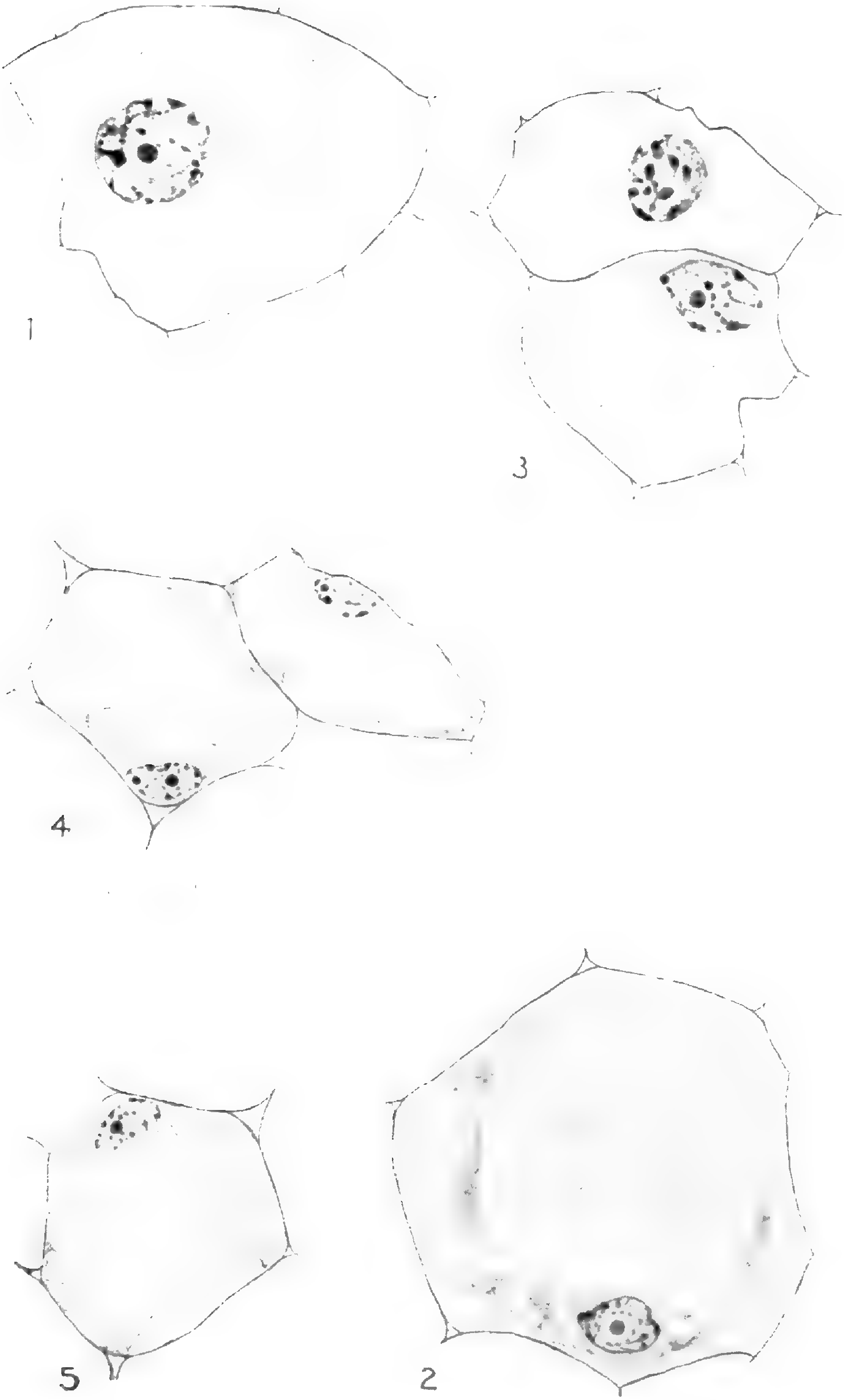
FIG. 1. Subepidermal cell from a perianth part with nucleus almost centrally placed in the vacuolated cytoplasm. A small stellate crystal appears to lie in one of these vacuoles.

FIG. 2. Crystal-containing cell from the perianth. The protoplast is shrunken and drawn away from the cell wall but in the large central vacuole appears a small crystal with a very delicate strand-like attachment to the vacuolar membrane.

FIG. 3. A normal parenchymatous cell from a perianth part with a crystal-containing cell of approximately equal size adjoining it.

FIG. 4. Two cells from the pith of the central axis of the spadix, contrasting the isodiametric shape of the larger aggregate crystal-containing cell with the adjoining cell. Nuclei and primordial utricle with chloroplasts are comparable in the two.

FIG. 5. A large aggregate of crystals occupying almost the entire lumen of the cell. Some of the crystals nearly reach the cell wall by extending into the thin primordial utricle. Nucleus still clearly visible.



GAISER CRYSTALS OF ANTHURIUM

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1923

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Addams, R. M. The effect of the hydrogen ion on the protoplasm of the root hairs of wheat. Am. Jour. Bot. **10:** 211–220. *pl. 23.* 18 Ap 1923.

Allen, W. E. Studies of catches of marine phytoplankton made by aid of the Kofoid bucket in 1921. Ecology **4:** 74–80. 21 F 1923.

Arrhenius, O. Statistical investigations in the constitution of plant associations. Ecology **4:** 68–73. 21 F 1923.

Artschwager, E. F. Anatomical studies on potato-wart. Jour. Agr. Research **23:** 963–968. *pl. 1–5.* 24 Mr 1923.

Artschwager, E. F. Occurrence and significance of phloem necrosis in the Irish potato. Jour. Agr. Research **24:** 237–246. *pl. 1–5.* 21 Ap 1923.

Bailey, I. W. Notes on Neotropical ant-plants. II. *Tachigalia paniculata* Aubl. Bot. Gaz. **75:** 27–41. *pl. 1, 2 + f. 1–3.* 23 Mr 1923.

Bailey, J. W. The passing of our forest mosses. Bryologist **26:** 20–22. *pl. 3.* 16 Ap 1923.

Bates, C. G. Physiological requirements of Rocky Mountain trees. Jour. Agr. Research **24:** 97–164. *pl. 1–7* + *f. 1–4.* 14 Ap 1923.

Belling, J., & Blakeslee, A. F. The reduction division in haploid, triploid and tetraploid Daturas. Proc. Nat. Acad. Sci. **9:** 106–111. 15 Ap 1923.

Berry, E. W. Tertiary plants from the Andes of Cajamarca, Peru. Am. Jour. Sci. **205:** 239–246. Mr 1923.

Includes 3 new species.

Blake, S. F. New composites from Salvador. Jour. Washington Acad. Sci. **13:** 143–146. 19 Ap 1923.

Rensonia, gen. & sp. nov., and new species in *Vernonia* (1) and *Zexmenia* (1).

Blake, S. F. Notes on the North American species of *Limonium.* Rhodora **25:** 55–60. 9 Ap 1923.

Blake, S. F. *Oenothera perennis* L. var. *rectipilis* (Blake) comb. nov. Rhodora **25:** 47. 6 Mr 1923.

Blake, S. F. Three new composites from Bolivia. Proc. Biol. Soc. Washington **36:** 51–54. 28 Mr 1923.

New species in *Erigeron* (1), *Aspilia* (1), and *Calea* (1).

Boswell, V. R. Dehydration of certain plant tissues. Bot. Gaz. **75:** 86–94. *f. 1–7.* 23 Mr 1923.

Brandes, E. W., & Klaphaak, P. J. Cultivated and wild hosts of sugar-cane or grass mosaic. Jour. Agr. Research **24:** 247–262. *pl. 1–4.* 21 Ap 1923.

Breazeale, J. E. Nutrition of plants considered as an electrical phenomenon. Jour. Agr. Research **24:** 41–54. *f. 1–5.* 7 Ap 1923.

Brison, F. W. Variations in pecans. Jour. Hered. **13:** 367–369. *f. 16.* 25 Ap 1923.

Britton, N. L., & Standley, P. C. Three new plants of the family Rubiaceae from Trinidad. Jour. Washington Acad. Sci. **13:** 105–107. 19 Mr 1923.

New species in *Evea* (1) and *Urceolaria* (1).

Brooks, F. G. Wild odors and where to find them. Nat. Mag. **1:** 49–51. Mr 1923. [Illust.]
Odors of plants and flowers.

Brownell, L. W. The American beech tree. Nat. Mag. **1:** 43–45. Ap 1923. [Illust.]

Brownell, L. W. The earliest wild flowers. Nat. Mag. **1:** 43–46, 54. Mr 1923. [Illust.]

Brownell, L. W. The Sugar Maple. Nat. Mag. **1:** 17–19. Mr 1923. [Illust.]

Burnham, S. H., & Latham, R. A. Flora of the town of Southold, Long Island. Torreya **23:** 25–31. Ap 1923.

Burns, G. P. Measurement of solar radiant energy in plant habitats. Ecology **4:** 189–195. *f. 1–3.* 31 My 1923.

Campbell, D. H. An interesting liverwort. Science II **57:** 384, 385. 30 Mr 1923.

Campbell, D. H. Australian botanical notes. II. Victoria, South Australia and West Australia. Am. Jour. Bot. **10:** 173–186. *pl. 21, 22.* 18 Ap 1923.

Chibnall, A. C. A new method for the separate extraction of vacuole and protoplasmic material from leaf cells. Jour. Biol. Chem. **55:** 333–342. Mr 1923.

Clausen, R. E., & Goodspeed, G. H. Inheritance in *Nicotiana tabacum.* III. The occurrence of two natural periclinal chimeras. Genetics **8:** 97–105. *pl. 1.* Mr 1923.

Clayton, E. E. The relation of soil moisture to the *Fusarium* wilt of the tomato. Am. Jour. Bot. **10:** 133–147. *pl. 13–15.* 30 Mr 1923.

Clayton, E. E. The relation of temperature to the *Fusarium* wilt of tomato. Am. Jour. Bot. **10:** 71–88. *pl. 8–11.* 2 Mr 1923.

Cole, J. S., & Mathews, O. R. Use of water by spring wheat on the Great Plains. U. S. Dept. Agr. Bull. 1004: 1–33. *f. 1–10.* 31 Mr 1923.

Collins, J. L. Culture of *Crepis* for genetic investigations. Jour. Hered. **13:** 329–336. *f. 23–26.* 10 Mr 1923.

Cook, M. T. Plant cancers. Jour. New York Bot. Gard. **24:** 70. Mr 1923.

Cook, O. F. Diversity of internode individuals. Jour. Hered. **13:** 323–328. *f. 19–22.* 10 Mr 1923.

Cooper, W. S. The recent ecological history of Glacier Bay, Alaska: I. The interglacial forests of Glacier Bay. Ecology **4:** 93–128. *f. 1–15.* 31 My 1923.

Davidson, A. New plants from S. California. Bull. S. California Acad. Sci. **22:** 56. Mr 1923. [Illust.]

New species in *Aster* (1) and *Dudleya* (1).

Davis, A. R., Hoagland, D. R., & Lipman, C. B. The feeding power of plants. Science II **57:** 299–301. 9 Mr 1923.

Denslow, H. M. Passaic County, N[ew] J[ersey]. Torreya **23:** 31, 32. Ap 1923.

Reports plants found therein.

Detlefsen, J. A., & Ruth, W. A. An orchard of chestnut hybrids. Jour. Hered. **13:** 305–314. *f. 7–13.* 10 Mr 1923.

Dickson, J. G. Influence of soil temperature and moisture on the development of the seedling blight of wheat and corn caused by *Gibberella Saubinetii.* Jour. Agr. Research **23:** 837–870. *pl. 1–6 + f. 1–14.* Mr 1923.

Dodge, B. O. Origin of the central and ostiolar cavities in the pycnidia of certain fungus parasites of fruits. Jour. Agr. Research **23:** 743–760. *pl. 1–6 + f. 1.* 3 Mr 1923.

Doolittle, S. P., & Walker, M. N. Cross-inoculation studies with cucurbit mosaic. Science II **57:** 477. 20 Ap 1923.

Etter, A. Polyembrony developed under experimental conditions in certain polypodiaceous ferns. Bull. Torrey Club **50:** 95–108. *pl. 4 + f. 1–7.* 16 Mr 1923.

Faris, J. A. Anthracnose of the Boston Fern. Mycologia **15:** 89–95. *pl. 8, 9.* 30 Mr 1923.

Fawcett, H. S. Gummosis of *Citrus.* Jour. Agr. Research **24:** 191–236. *pl. 1–8.* 21 Ap 1923.

Fernald, M. L. *Empetrum nigrum* L., forma *purpureum* (Raf.), n. comb. Rhodora **25:** 83. 24 Ap 1923.

Fernald, M. L. The estuarine *Bidens* of the Miramichi [New Brunswick]. Rhodora **25:** 43, 44. 6 Mr 1923.
Bidens hyperborea arcuans, var. nov.

Fernald, M. L. Another orchid new to New England. Rhodora **25:** 47, 48. 6 Mr 1923.
Habenaria cristata (Michx.) R. Br. in Massachusetts.

Fernald, M. L. Nomenclatorial transfers in *Mariscus.* Rhodora **25:** 49–54. 9 Ap 1923.

Fernald, M. L. The identities of the sand cherries of eastern America. Rhodora **25:** 69–74. 24 Ap 1923.

Forbes, R. D. The passing of the piney woods. Am. For. **29:** 131–136, 185–186. Mr 1923. [Illust.]

Frost, H. B. Heterosis and dominance of size factors in *Raphanus.* Genetics **8:** 116–153. *f. 1–4.* Mr 1923.

Fuller, G. D. An edaphic limit to forests in the prairie region of Illinois. Ecology **4:** 135–140. *f. 1–3.* Ap 1923.

Gardner, M. W., & Kendrick, J. B. Bacterial spot of cowpea. Science II **57:** 275. 2 Mr 1923.

Garner, W. W., & Allard, H. A. Further studies in photoperiodism, the response of the plant to relative length of day and night. Jour. Agr. Research **23:** 871–920. *pl. 1–19.* 17 Mr 1923.

Gates, F. C. Influence of moonlight on movements of leguminous leaflets. Ecology **4:** 37–39. 21 F 1923.

Gerry, E. Recent observations on the effects of turpentining on the structure of second-growth slash and longleaf pines. Jour. For. **21:** 236–241. *pl. 1, 2.* Mr 1923.

Gleason, H. A. Evolution and geographical distribution of the genus *Vernonia* in North America. Am. Jour. Bot. **10:** 187–202. *f. 1–3.* 18 Ap 1923.

Gleason, H. A. *Windsorina,* a new genus of Rapateaceae. Bull. Torrey Club **50:** 147–152. *pl. 7.* 7 Ap 1923.
Windsorina, gen. and sp. nov., from Guiana.

Godfrey, G. H. Gray mold of castor bean. Jour. Agr. Research **23**: 679–716. *pl. 1–13* + *f. 1–5*. 3 Mr 1923.

Gruner, J. W. Algae, believed to be Archean. Jour. Geol. **31**: 146–148. *f. 1–3*. Mr 1923.

Haas, A. R. C. Pot culture with barley in soil from a long-time fertilizer experiment. Bot. Gaz. **75**: 95–102. *f. 1–4*. 23 Mr 1923.

Haley, D. E. Availability of potassium in orthoclase for plant nutrition. Soil Sci. **15**: 167–180. Mr 1923.

Harlan, H. V., & Pope, M. N. The use and value of back-crosses in small-grain breeding. Jour. Hered. **13**: 319–322. 10 Mr 1923.

Harter, L. L., Lauritzen, J. I., & Weimer, J. L. Motile necrosis of sweet potatoes. Phytopathology **13**: 145, 146. 13 Mr 1923.

Harter, L. L., & Weimer, J. L. Anylase in the spores of *Rhizopus Tritici* and *Rhizopus nigricans*. Am. Jour. Bot. **10**: 89–92. 2 Mr 1923.

Haupt, A. W. Cell structure and cell division in the Cyanophyceae. Bot. Gaz. **75**: 170–190. *pl. 7*. 20 Ap 1923.

Hayes, H. K. Inheritance of kernel and spike characters in crosses between varieties of *Triticum vulgare*. Univ. Minnesota Stud. Biol. Sci. 4: 163–184. Ja 1923.

Heald, F. D., Zundel, G. L., & Boyle, L. W. The dusting of wheat and oats for smut. Phytopathology **13**: 169–183. *f. 1*. 4 Ap 1923.

Heard, O. O. *Schweinitzia*. Maryland Acad. Sci. Bull. **3**^{2}: 9, 10. Ap 1923.

Hensel, R. L. Recent studies on the effect of burning a grassland vegetation. Ecology **4**: 183–188. *f. 1*. 31 My 1923.

Hoffer, G. N., & Carr, R. H. Accumulation of aluminum and iron compounds in corn plants and its probable relation to rootrots. Jour. Agr. Research **23**: 801–824. *pl. 1–21*. 10 Mr 1923.

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New names and the final members of new combinations are in **bold face type.**